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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

**SHIFTING THE PARADIGM OF TRAUMA MEDICINE TO
POSITIVELY INFLUENCE CRITICAL MORTALITY
RATES FOLLOWING A MASS CASUALTY EVENT**

by

Dana L. Hall

June 2009

Thesis Advisor:
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**SHIFTING THE PARADIGM OF TRAUMA MEDICINE TO POSITIVELY
INFLUENCE CRITICAL MORTALITY RATES FOLLOWING A MASS
CASUALTY EVENT**

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Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF ARTS IN SECURITY STUDIES
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from the

**NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

Medical providers, patients, and their families have always been able to enjoy the abundance of U.S. society. When medical resources exceed the demand for care, all necessary medical resources are used to improve the health or save the life of each individual. However, the health care system in the U.S. is severely under-prepared to care for hundreds to thousands of victims simultaneously from a mass casualty event (MCE). The influx of patients would severely overwhelm emergency rooms. Although global events indicate the U.S. must prepare, the medical community has historically been uncomfortable openly discussing standards of care during a mass casualty event because it is equated with the “rationing” of care. This thesis demonstrates through four case studies that critical mortality was reduced and a greater number of critically injured survived due to improved triage accuracy, rapid movement to definitive care, implementation of damage control procedures, and coordinated and collaborative regional preparedness. The medical community must appreciate that altering standards of care during a MCE does not reduce overall care rendered; rather care is strategically directed, so critical mortality is lowered.

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GLOSSARY

A-B-C	algorithm used in civilian trauma setting—Airway, Breaths, Circulation
ALS	Advanced Life Support
C-B-A	algorithm used in military medical operation—Circulation, Breaths, Airway
CPR	Cardio-Pulmonary Resuscitation
Critical Mortality	the number of deaths in the critically injured survivors (number of deaths among critically injured / number of critically injured survivors).
CSH	Combat Support Hospital used in a military medical operation
Damage Control	surgeries / procedures done to stabilize the victim rather than provide all care necessary
Definitive Care	completion of recommended treatment to include diagnosis, treatment, and administration of necessary medications
Diversion	when the health care system is overloaded and all internal capacity is exhausted, patients are brought to other facilities
ED	Emergency Department
EM	Emergency Medicine
EMAC	Emergency Management Assistance Compact
FST	Forward Surgical Team; used in a military medical operation and move just behind the troops to provide the first level of trauma care
GME	Graduate Medical Education
Golden Hour	the 60 minutes following traumatic injury to initiate trauma care when a victim's chances of survival are greatest
HPP	Hospital Preparedness Program administered by the Department of Health and Human Services to enhance the ability of hospitals and health care systems to prepare for and respond to public health emergencies

Incident Command System (ICS) principles and organizational structure of command during an incident

Injury Severity Scale (ISS) an anatomical scoring system ranging from 0-75 that provides an overall numerical score for a victim with multiple injuries

INSALUD Spain's National Institute of Public Health Care

KIA Killed in Action

Mass Casualty Event (MCE) any event that exceeds the resources of the health system or network for an extended period of time

NDMS National Disaster Medical System

NRF National Response Framework

Over-triage (OT) non-critically injured victims who are triaged as being critically injured when they are indeed not

Scoop and Run (S&R) process when victim is rapidly extricated from the field and brought to the trauma team with minimized pre-hospital medical interventions

Sequential Organ Failure Assessment Scores (SOFA) a score that measure organ failure

Stay and Play (S&P) process when victim is stabilized in the field prior to being transported

Surge Capacity the ability to expand beyond normal operations for an extended period of time

TCCC or TC³ Tactical Combat Casualty Care—treatment guidelines for casualties in the battle field

Triage the process of assessing and sorting injured victims to prioritize treatment and allocate resources

Triage Efficiency/Accuracy the critically injured are identified in an accurate and timely matter and sorted and distributed based on their criticality

Under-triage critically injured victims who are not triaged as such and thus are not assigned to immediate care

USSOCOMM U.S. Special Operations Command

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I. INTRODUCTION

כל המאבד נפש אחת - מעלה עליו הכתוב כאילו קיים עולם
מלא, וכל המקיים נפש אחת - מעלה עליו הכתוב כאילו איבד
עולם מלא

"Whoever destroys a soul, it is considered as if he destroyed an entire world.

And whoever saves a life, it is considered as if he saved an entire world."

Jerusalem Talmud, Sanhedrin 4:1 (22a)

A. PROBLEM STATEMENT

Current mass casualty capacity in the United States is insufficient to provide care to a surge of critically ill or injured patients. Despite the abundance in U.S. society, one could even argue that today's U.S. health care system operates in a disaster mode on a regular basis. A routine day in the emergency departments is plagued with long waits, serious overcrowding, resource constrictions, and frequent ambulance diversions due to internal capacity being exhausted (Sasser et al., 2007, p. 1). Yet the philosophies and values of U.S. medicine are to provide health care services of unlimited means.

The situation in U.S. emergency departments (EDs) has been quickly deteriorating. The number of ED visits from 1996 to 2006 increased 32 percent from 90.3 million to 119.2 million while, the number of ED decreased 5 percent from 4019 to 3833 in the same 11-year period. Thus the population based rates increased from 34.2 to 40.5 / 100 persons (Pitts, Niska, Xu, & Burt, 2008, p.2). Seventeen point four percent of the 119.2 million visits in 2006 were accountable to the uninsured that do not have primary care providers and often seek routine health care in EDs (Pitts et al., 2008, p. 2).

The well-known adage in emergency management is that all disasters are local. No different is the case with health care. Health care following a disaster is local. During a disaster, terrorist event, or biological disease outbreak, the hospital component of the health care system bears the burden of the victims/patients (Kelen et. al., 2006, p.1984; Sasser et al., 2007, p. 1). The hospitals closest to the disaster epicenter receive the most patients, except when there is no clear epicenter.

U.S. emergency rooms are sorely unprepared for daily operations, let alone to handle the surge of patients immediately following a disaster. U.S. physicians are not adequately trained to handle the injury types most common with explosions, the most pervasive of terrorist's techniques. Federal systems such as the National Disaster Medical System (NDMS) can only provide assets several days after an event. Emergency Management Assistance Compact (EMAC) is fraught with issues that can delay immediate care. Plans are written but not exercised, and federal agencies are creating solutions which may be more detrimental than beneficial.

Most experts, health care administrators, and health care providers agree that during a mass casualty event, hospitals and health care systems will not be able to provide services in the manner in which they do on a routine basis. Peer-reviewed articles and professional presentations are beginning to address "altered" or "situational" standards of care as a way of dealing with shortages of personnel, equipment, supplies and time. Events such as Hurricane Katrina demonstrate it is most certainly imperative that the medical community start to tackle this ethically complex issue with rigor. However, it must be cautioned that the recommendations are not entombed simply in tactics. A comprehensive strategic assessment must be included so that the paradigm of mass trauma health care delivery will focus on reducing critical mortality rather than on how to best ration resources. The critical mortality rate is defined as the number, as a percentage, of all critically injured survivors who died (Frykberg, 2002, p. 204). The potential for enormous benefits that can be obtained in lives saved by changing the paradigm of health care delivery following a mass trauma casualty event from one focused on the individual to one that is population based needs to be examined.

B. RESEARCH QUESTION

- When does the current practice of “good medicine” become “bad medicine”?
- If the current standard of care is not the best standard of care during a mass casualty event (MCE) then what is?
- What can be learned by examining discrete MCEs and distinct health care delivery systems throughout the world?

C. ARGUMENT: MAIN CLAIMS, WARRANTS, EVIDENCE AND CHALLENGES

Advance planning for the delivery of health care during a MCE will mitigate crisis decision making at the time of an event. This will allow for the optimization of resources and reduced critical mortality rates. Improving outcomes will focus on the overall needs of the population rather than the individual. This course of action will do the most good for the greatest number and result in increased overall survival.

Emergency mass casualty response is triggered when the resource demands outstrip the resources available. It is incremental in nature and depends on the situation at hand. Obviously this is a very complex process that requires judicious consideration and ethical review. The decision to deploy situational emergency mass casualty care can never be made lightly or in isolation as this is a deviation from the typical standard of care. For successful implementation, doctors and other critical care health care professionals must understand and be trained to triage within a MCE framework.

There is a general feeling of reluctance by the medical community to discuss deviating from the typical standard of care although reports from Hurricane Katrina indicate that medical providers were forced to. Health professionals are very concerned about the liability involved in situational emergency mass casualty care. It is the role of professional societies to define the standards of care during a MCE. As such, it will normalize the practice in disaster situations.

D. SIGNIFICANCE OF RESEARCH

1. The Literature

The literature review indicates that government agencies are realizing that disasters create more health and medical surge than current health care delivery has capacity. The research of this thesis will go a step further and examine how mass casualty health care is handled in numerous other settings. From this analysis, recommendations will be made to U.S. health and medical community from the best practices of other systems.

2. Future Research Efforts

The topic of situational standards of care is only coming to the forefront of the literature in the U.S. health and medical community. Implementation of situational standards of care is limited at the local level. Few health care systems or regional health authorities have developed standards of care to be activated during a MCE. This research takes the next logical step and looks at what has been working throughout the world. Continued research is necessary both in this specific part of the problem and with the acceptance of the community that is served.

3. Immediate Consumer (Identify)

The audiences of this thesis are health and medical providers and health system administrators along the entire continuum of the U.S. health care delivery—from pre-hospital through to the emergency room and on to definitive care. Additionally, this thesis is being written for consideration by health care professional societies to aide them in developing standards of care during a MCE that will provide guidance to their members and establish professional criteria to protect providers who might find themselves in this less than desirable predicament.

4. HS Practitioners and Leaders Nationally

Public health and medical issues are just emerging as disciplines within the homeland security community. Given that homeland security is made up of professionals from a myriad of disciplines it is imperative that each profession share its research and expertise in such a way as to make it understandable within the homeland security community. This thesis will outline the crisis in the current health care system and demonstrate how fragile the system is. When taxed by a terrorist event or national disaster, it will be unable to surge to accommodate the additional load. Since health care is something that all Americans expect to be available when needed, this research should prove to be eye-opening to all members of the homeland security and motivate on-going research and investigation into improving our health delivery system.

E. METHODOLOGY

The methodology for this research will be a policy options analysis examining the trauma health care systems of Spain, the United Kingdom, Israel, and the U.S. military. In particular, how each of these systems handles mass casualty events will be explored and analyzed in relation to critical mortality rates. The analysis will be fused so tangible recommendations can be made to the U.S. health and medical communities on how best to adopt and implement incremental situational standards of care for mass trauma care in the U.S.

The systems that are being selected have met several criteria. Countries selected are westernized. The government structure is more similar to the U.S. than countries in other parts of the world. The values and expectations of the general population are assumed to be somewhat similar. Medical training and practice among health care providers is also being assumed to be somewhat similar.

Each of these systems has had either one major representative event or as in the case of Israel and the U.S. military, exists in an on-going environment that involves mass

casualty care. Four systems are examined to give a broad scope of data to be analyzed and to represent the continuum of mass casualty scenarios that are faced by health colleagues throughout the world.

II. LITERATURE REVIEW

Explosions are the most common cause of casualties associated with terrorism (Arnold, Tsai, Halpern, Smithline, Stok, & Ersoy, 2003, p.221). As terrorists have become more sophisticated, extensive coordination allows numerous cities to be targeted simultaneously. With numerous cities involved, the effect is dramatically augmented. Depending on the characteristics of the bombing, the local emergency medical resources can be easily overwhelmed. Health care officials across this country are anticipating profound shortcomings in the current health care system in caring for the surge of victims following a disaster (Sasser et al., 2007, p. 1; Kelen et. al., 2006, p. 1984). This literature review examines the body of literature that deals with health care delivery in the United States following a mass casualty event, particularly a bombing.

Terrorist bombings are a “predictable surprise” (Sasser et al., 2007, p. 5). Bombings are far more pervasive in the U.S. than is generally realized, and the literature indicates that hospitals are not prepared to handle them (United States House of Representatives Committee on Oversight and Government Reform Majority Staff, 2008). According to the FBI between 1988 and 1997, there were 17,579 bombings in the United States, an average of 5 per day (Davis & Lee, 2004). Explosives remain an inexpensive way for terrorist to disrupt society while advancing their cause. As terrorists have become more sophisticated, extensive coordination allows numerous cities or sites to be targeted simultaneously, as was the case on September 11, 2001.

A. DEFINITION OF MASS CASUALTY CARE

A Mass Casualty Event (MCE) is not defined by a set size but rather as any event that exceeds the resources of the health system or network for an extended period of time. In a small community, an event with ten casualties may exceed the capacity of the local system and be considered a MCE. Yet that same event in a large major center, assuming resources were not over-burdened, would not be considered a MCE. The principles of health care delivery during a MCE shift focus to the treatment of the population as a whole rather than the individual.

During a disaster, the hospital component of the health care system cares for the burden of the victims/patients (Kelen et al., 2006, p. 1984). The hospital closest to the disaster epicenter will receive the most patients except when there is no clear epicenter such as a wide-spread bioterrorism event or pandemic infectious disease. In the first 24 hours after the September 11 plane crashes in New York City, over 500 victims presented for emergency care at a hospital four blocks from ground zero, while another 300 sought care at the next hospital which was within one mile (Pesola, Dujar, & Wilson, 2002, pp. 220-2). On March 11, 2004, ten nearly simultaneous bombings occurred in Madrid killing 177 people and injuring nearly 2000, of which 272 patients sought care within the first 2.5 hours at the closest hospital (Peral-Gutierrez de Ceballos et al., 2005, p. 104).

The Hippocratic Oath delineates societal values in the ethical practice of medicine. In it, physicians promise to keep the good of the patient as the highest value. Health care in the U.S. is delivered with the highest standards. U.S. medical practitioners are trained to that level and patients and their families demand it. Each individual patient receives all the resources necessary. However, during a mass casualty event that involved hundreds to thousands or even tens of thousands of people; the demands placed on the local public health and medical system can easily be overwhelmed for a varying length of time depending on the circumstances of the situation. Medical providers, patients, and their families have always been able to enjoy the abundance of U.S. society. Medicine has always had the luxury to make life or life decisions. Rarely has the health care delivery system been placed in situations where decisions had to be made that were life and death situations—where medical providers were forced to work outside the standards of which they were trained and comfortable.

B. DEFINITION OF SITUATIONAL STANDARDS OF CARE

Standards within medical care define the type of care that is given, to whom, by whom, where, and when (Health Systems Research, Inc. [HSR], 2005, pp. 7-8). Standards define the clinical intervention based on current medical practice and established clinical guidelines. These guidelines are structured based on peer-reviewed research and evidence based outcomes. Standards define who should receive health care

based on their condition and likelihood of response to the treatment. They also determine which professional type has the ability to provide the care based on their certification and/or licensure, their scope of practice, and the law. Standards also define the location of where care can occur and delineate who has authority. Under normal conditions, when medical resources exceed the demand for care, it is assumed that all necessary medical resource would be used to improve the health or save the life of each individual.

Situational Standards of Care is a broad sweeping term that can refer to many different components within a health care system. The phrase has generally been defined as a shift in providing care and allocating scarce resources, supplies or personnel that saves as many lives as possible, rather than focusing on saving the individual. Examples of Situational Standards of Care may include pre-hospital operations or using alternative sites such as schools, houses of worship, or hotels for care rather than a hospital. It may mean expanding the scope of practice for certain professional types. For instance, nurses may provide services usually only provided by physicians. Or it could mean legislation is in place so that providers from another state are able to provide services contingent on an executive order from the governor. Infection control standards could be modified so rather than individual isolation; groups with similar exposure can be isolated together. In the appropriate situation it could mean that the trauma field triage criteria are put into place. These are only brief examples of some of the components of Situational Standards of Care discussed in the U.S. literature. Situational Standards of Care is a very complicated equation with numerous variables that can all be adjusted in order to preserve as many lives as possible.

C. RECENTLY PUBLISHED FEDERAL GOVERNMENT STUDIES

Numerous articles have been written in the United States dealing with medical capacity during disaster. Terminology used in the literature has included *altered standards of care*, *surge capacity*, *field triage criteria*, *population based health care*, *rationing* and *mass casualty preparedness*. For the purposes of this literature review, all terms will be used interchangeably, although it is important to note that some terms are perceived to be more acceptable than others. Several of the major works were written

recently by agencies within the U.S. government, indicating that there is a gap in the health care this country is able to provide and the level of disaster and destruction that has been demonstrated recently in Madrid, Spain; New York City; and London, England.

The Centers for Disease Control and Prevention (CDC) published *In a Moment's Notice: Surge Capacity for Terrorist Bombings* in April 2007. The Agency for Healthcare Research and Quality (AHRQ) published *Altered Standards of Care in Mass Casualty Events* in April 2005. Likewise, numerous state standards and guidelines exist within the literature.

The term *Altered Standards of Care* was the phrase used in the Agency for Healthcare Research and Quality (AHRQ) publication *Altered Standards of Care in Mass Casualty Events*. *Altered Standards of Care* is a broad sweeping term that can refer to many different components within a health care system. The phrase has generally been defined as a shift in providing care and allocating scarce resources, supplies or personnel that saves as many lives as possible, rather than focusing on saving the individual.

Altered Standards of Care is a very complicated equation with numerous variables that can all be adjusted in order to preserve as many lives as possible. The literature indicates that countries that deal with mass casualties more frequently have plans that are integrated in to their daily operations. Much can be learned from these health systems and can be incorporated into the daily operations in the United States. Unfortunately, no literature was identified that detailed the exercising or deployment of *Altered Standards of Care* in the health care system during a true or simulated disaster.

In April 2005, the U.S. Department of Health and Human Services conducted a study to examine the use of *Altered Standards of Care* in mass casualty events. The study included identifying what planners need to know and key guiding principles necessary to develop effective health and medical response plans (HSR, 2005, pp. 1-2). Numerous key findings were identified. These included:

- The goal of *Altered Standards of Care* is to maximize the number of lives saved. Rather than do everything possible to save one life, it is necessary to allocate scarce resources to save as many lives as possible.

- Health systems do not have adequate guidance or plans to implement Altered Standards of Care when needed during a mass casualty event.
- The allocation of resources must be judge to be fair and flexible so it can be adjusted to the size and scope of the event accordingly.
- The plan needs to address all types of disasters (bombings, bioterrorism, etc).
- Qualified mass casualty providers are necessary for the appropriate implementation of Altered Standards of Care.
- To ensure effective response, consideration must be given to non-medical issues such as who has the authority to activate, legal liabilities, reimbursement issues, and public relations (HSR, 2005, pp 2-3).

The Department of Health and Human Services drafted guidance for health systems to consider when developing their Altered Standards of Care Plans. The recommended actions from this documented included:

- Develop general and event-specific plans for the allocation of scare medical resources during a mass casualty event.
- Implement processes to address non-medical issues that impact health care delivery including finances, public relations, and risk communication.
- Identify local, state and federal law that affect the delivery of health care and consider appropriate modifications.
- Develop and utilize searchable databases to verify credentials of health providers who arrive on-site as volunteers.
- Ensure coordinated health and medical leadership for the response, utilizing Hospital Emergency Incident Command System (HEICS).
- Continually train all staff (both medical and non-medical) to effectively respond in a mass casualty event.
- Develop a planning guide to assist preparedness planners' efforts. Planning must occur both within the individual health system as well as throughout the greater region to ensure adequate coordination (HSR, 2005, pp 3-4).

Both the CDC and AHQR publications demonstrate an acknowledgement that the health care system in this country is severely under prepared to handle disasters. On

routine days, emergency departments are overcrowded and resources constrained (Sasser et al., 2007, p. 1). The literature was in agreement that emergency room capacity in the United States is diminished and would be severely overwhelmed with the influx of patients from a disaster.

The literature indicates numerous triage systems currently being used across United States' emergency rooms, including Smart Triage and Rapid Transport (START), JumpSTART (a pediatric modification to START), Pre-Hospital Trauma Life Support (PHTLS), and Advance Trauma Life Support (ATLS) (Davis & Lee, 2004). These systems are predicated on resources and facilities being fully available to the patient (HSR, 2005, p.5). Additionally, the literature did not recommend one specific methodology for disaster field triage that is agreed upon (HSR, 2005, p. 11).

The triage system being used by the military is Tactical Combat Casualty Care (TC³) for injured soldiers (Davis & Lee, 2004). The U.S. military has adopted new strategies which have resulted in improved outcomes. Death rates after wounding have been reduced significantly from 42 percent at the time of the Revolutionary War to less than 10 percent in the current conflict in Iraq. Of course, many factors can be contributing to this improved outcome. Even between the first Gulf War to the current conflict the death rate has been decreased from 24 percent to less than 10 percent (Gawande, 2004, p. 2472).

No article was identified that described the recommendations from the CDC or AHQR publications occurring in U.S. emergency rooms. The CDC determined that 75 percent of hospitals have disaster plans that had a bombing response component yet only 20 percent had ever exercised the plan (National Center for Injury Prevention and Control (Sasser et al., 2007, p. 7). It is additionally documented that many of the civilian staff are not adequately trained to provide emergency care for certain types of disaster injuries. Civilian emergency physicians routinely care for injuries such as blunt and penetrating trauma. They have much less experience dealing with crush and blast injuries or total body disruption injuries consistent with bombings. Until physicians and providers have the on-going training they need, they will not be prepared to handle the surge of patients with injuries outside their normal patient profile. In a survey published in 2004 in the

Journal of Trauma, 27 percent of trauma surgeons reported that they were not prepared to manage blast injuries, a most common multi-system life-threatening injury associated with bombings (Ciralo et al., 2004, p. 1037).

A weakness noted in the CDC report was that the panel of experts was composed predominately of physicians, which influenced the content of the writing. Topics such as “drugs and pharmaceutical supplies” and “nursing care” were distilled to a tactical to-do list and not given the full consideration that would be required to develop a comprehensive plan. This demonstrates the complexity of this issue and the need for all disciplines to be involved in the planning. Of additional note, none of the literature identified for this review written by American authors or government agencies drew from lessons learned in other countries.

D. RECENTLY PUBLISHED CHEST STUDIES

In May of 2008, several supplements were published following the Task Force for Mass Critical Care Summit that occurred January, June, and December 2007. The supplements were written by a multidisciplinary panel of 37 critical care experts spanning numerous fields. They examined current critical care preparedness and response capabilities so as to suggest a framework for surge capacity in a mass casualty critical care environment. The task force understood that although MCEs frequently occur throughout the world, the medical community in the U.S. has limited experience providing care during a MCE. Four unique yet related documents yielded from the task force’s work. These included:

- Current Capabilities and Limitations;
- A Framework for Optimizing Critical Care;
- Medical Resources for Surge Capacity;
- A Framework for Allocation of Scarce Resources in Mass Critical Care.

When the suggestions came forth from the task force, they made quite a stir in the medical community. Words such as *limitations*, *rationing*, *withholding*, and *withdrawing* were used in the recommendations which roused heated discourse. Recommendations

started out innocuously enough—every hospital with an intensive care unit (ICU) should plan in a regional and coordinated fashion. The recommendations continued:

- ICUs need to be prepared to handle triple their usual bed count;
- Hospitals must plan to deliver care for 10 days without external assistance;
- Every community must develop a graded/ situational response plan.

In the forth supplement, the recommendations examined the triage process advising that triage be a uniform approach. Triage decisions must rely on set objective and quantitative criteria as further delineated:

- Rationing of critical care will only occur after augmentation has been exhausted;
- Limitations will be commensurate with the true lack in resources;
- Restraints of critical care will occur uniformly;
- Equal emphasis should be given to withholding, as well as withdrawing care;
- Patients not meeting the criteria to receive critical care will receive palliative care.

The report defined inclusions and exclusion criteria to receive critical care. Exclusion criteria, in addition to little likelihood of survival, included sequential organ failure assessment scores (SOFA) and concomitant pre-existing chronic diseases. SOFA is a score that measure organ failure. Patients with SOFA scores that represented greater than or equal to 80 percent mortality were recommended for the exclusion category. Concomitant chronic diseases identified as exclusion criteria included metastatic malignant disease (cancers); end-stage organ failure of the heart, lung, or liver; unwitnessed cardiac arrest; and most controversial, age greater than 85 years (Devereaux et al., 2008, p. 60S).

The articles the published by the American College of Chest Physicians in the journal *CHEST* are not only revolutionary; they are also quite controversial among the medical communities. They were the first articles to be written by a panel of experts who

wrote so succinctly about the need for the medical community to agree to and adopt a set objective and quantitative criteria for triaging the victims of a mass casualty event when resources are constrained.

E. CENTRAL TENET(S) OF EXISTING U.S. DATA

Examination of the literature indicates that improved outcomes occur during a mass casualty event with improved triage accuracy. Effective triage accuracy is defined in the literature as identifying the critically injured in an accurate and timely matter and sorting them based on their criticality. Triage accuracy is then further driven by decreased over-triage rates and under-triage rates.

Over-triage is defined as the assignment of non-critically injured victims to immediate care even when the victim's injuries do not categorize them as critical. Excessive over-triage pulls limited resources from the truly critically injured to the population that has been over-triaged, spreading resources over an even greater number of people. Conversely, under-triage occurs when victims who are critically injured are not identified as such and are not assigned to immediate care.

A linear relationship between over triage rates and critical mortality rates has been demonstrated in the literature. This linear relationship was demonstrated in a retrospective analysis conducted by Eric Frykberg (see Figure 1). In events where the over-triage rate was low, the critical mortality was low. In events where the over-triage rates were high, the critical mortality rates were higher. Specifically, the 1983 Beirut Airport (BE) terrorist bombing had a very high over-triage rate of 80 percent and an elevated critical mortality rate of 37 percent. Likewise, the event labeled as CC in Figure 1 is the 1969 ground attack on the Chu Chi base camp during the Vietnam War. The over-triage rate was 75 percent with an elevated critical mortality rate of 33 percent.

At the other end of the linear relation, the 1974 Guildford pub (GP) bombing had a very low over-triage rate of 8.3 percent with a zero percent critical mortality rate. The Craigavon Area (CA) Hospital from 1972 to 1980 had an overall over triage of 20 percent and a critical mortality rate of only four percent. The Oklahoma City (OC) bombing of 1995 had a relatively low over-triage rate of 31 percent and a low critical

mortality rate of nine percent TL represents the 1974 London Tower bombing with an over-triage rate of 47 percent and a critical mortality rate of 10 percent (Frykberg, 2002, p. 207).

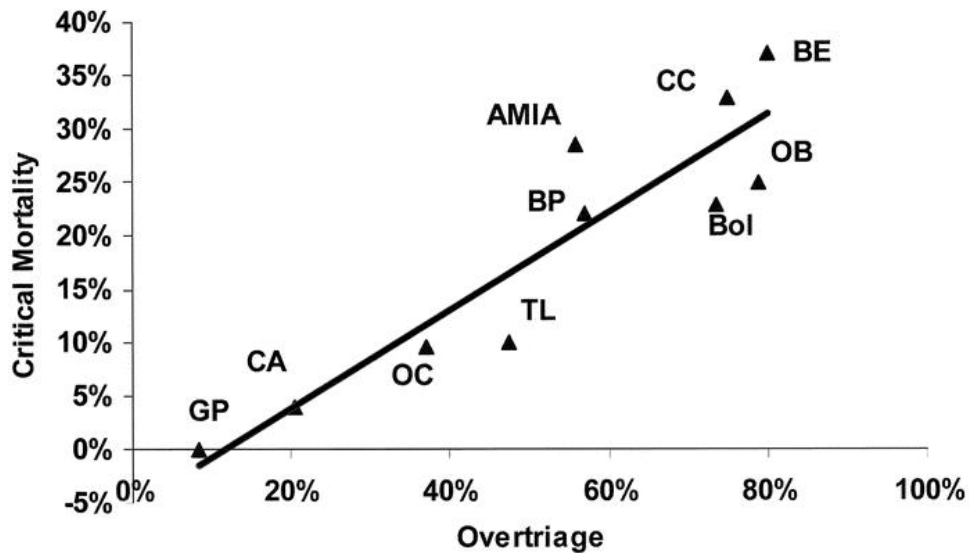


Figure 1. Over-triage Rate to Critical Mortality Rate, in 10 Terrorist Bombing Incidents from 1969 to 1995 (From Frykberg, 2002, p. 207)

Upon further examination of the literature, the theory that there is a linear relationship between over-triage rates and critical mortality rates is further validated in a retrospective review of mass-causality events in Israel from October 1, 2000 to September 1, 2004. During this period, 93 mass-casualty events occurred in Israel, of which 33 occurred in the city of Jerusalem. The study looked specifically at the events that occurred in Jerusalem and were handled by Hadassah Hebrew University Medical Center, the sole Level 1 Trauma Center in Jerusalem and a hospital that is unfortunately highly experienced at providing trauma care to victims of terrorism. The study reviewed 541 victims who presented to the emergency department of which 208 were admitted. Overall mortality was measured to be 8.5 percent (Aschkenasy-Steuer et al., 2005, p. 491). The remarkable low mortality rate is credited to several dynamic factors which increase triage accuracy which include the forward deployment of surgeons and anesthesiologists, immediate establishment of command and control, unidirectional victim flow, and “scoop and run.” These factors will be further examined in Chapter V.

Triage accuracy is improved with the reduction of over-triage. Yet the literature cautioned not to reduce over-triage rates so greatly that under-triaging inadvertently occurs. Under-triage is very life-threatening situation for the victim who was not accurately triaged. Under-triage rates are rarely reported in the literature, but research by Frykberg and Tepas indicates that an over-triage rate of at least 50 percent is necessary to reduce the potential critical mortality that possibly could occur when under-triage occurs (Frykberg & Tepas, 1988, p. 569). Although it is advisable to reduce over-triage rates, it important not to reduce it so greatly that the critically injured are not properly identified.

Over-triage rates and under-triage rates are not able to be determined until a retrospective analysis of the trauma care given is conducted. Criticality is determined using the Injury Severity Score (ISS). ISS is an anatomical scoring system that provides an overall numerical score for a victim with multiple injuries. ISSs range in value from 0-75. The ISS has a linear corollary relationship with mortality and morbidity and severity of injuries. A noted weakness of the ISS is that different body regions are not weighted differently. Thus different injury patterns can generate similar scores (Baker, O'Neill, Haddon, & Long, 1974, pp. 187-196). However, all scoring systems have their advantages and disadvantages. ISS is an established and well regarded tool in the medical community to assign criticality to victims with multiple injuries.

It is critical to remember not all disasters are the same. Caring for victims from a bombing that is immediate and destructive differs greatly from a caring for those affected by a biological event which is evolving and geographically widespread. Much of the literature reviewed looked specifically at mass casualty preparedness in relation to particular disaster type. This is helpful for targeting research specific to bombings. Some of the research was a bit too specific, such as looking specifically at ventilator rationing. Research that is too specific does not contribute significantly to the overarching changes that need to be addressed in the paradigm of U.S. health care delivery during a disaster.

F. GAPS IN THE LITERATURE

Further examination of the literature needs to be completed to understand what other countries who deal with bombings more frequently have put into place. In one

article, researcher Shimon Glick “defined ethical principles” valued by the U.S., Great Britain, Israel and Sweden (Glick, 2001, pp. 118-119). Israel and Sweden have listed mutual assistance and solidarity as values while the U.S. has listed choice. Table 1 delineates the values that shape health care delivery. Understanding these differences is imperative to know if what other countries are doing can be modified to be acceptable to the U.S. population that values choice as highly as it does.

Table 1. Values that Shape Health Care Delivery

United States	Great Britain	Israel	Sweden
Security	Fairness	Justice	Human Dignity
Savings	Efficiency	Mutual Assistance	Solidarity
Simplicity	Effectiveness	Equality	Efficiency
Responsibility	Responsiveness		
Choice	Integration		
Quality	Accountability		

G. AREAS THAT REMAIN UNKNOWN OR UNEXPLORED

The medical community, as well as health care leadership, has historically been very uncomfortable discussing situational standards of care openly because it is believed that the public equates situational standards of care with the “rationing” of care. It is feared that there will be loss in public confidence in a particular hospital, health system, or government agency. As such Situational Standards of Care plans have not been broadly implemented in local hospitals. Health care staff is not trained to the specific variables that can be altered, nor are they trained to understand the epidemiological differences among mass casualty events.

The 2008 publication of the *CHEST* articles following the Task Force for Mass Critical Care Summit spawned much heated discussion within the medical community, particularly with recommendations that fly directly in the face of the Hippocratic Oath such as the withdrawal of care or an age of 85 years or greater excluding a victim from receiving care. The *CHEST* studies stimulated much needed discussion in the community

and further research needs to be conducted to capture the medical community's perceptions about the delivery of trauma care during a mass casualty event when the resources are limited.

The previous reluctance to openly discuss situational standards of care has stymied necessary and life-saving planning efforts. Situational standards of care are only beginning to be addressed in the literature. Without proper addressing, medical providers are put into situations where they are not prepared nor are they protected legally. The decisions are made in the heat of the moment, as they were at the Superdome after Hurricane Katrina with the evacuation of New Orleans residents. This piece-meal approach does not allow for a comprehensive, systematic approach that considers all variables in concert, resulting in the most lives saved. Continuing research needs to be conducted to validate if in fact, situational standards of care are a contributing factor to reducing critical mortality rates and thus in preserving life, rather than a "rationing" of care.

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III. SPAIN

A. SPAIN'S HISTORY AND EVOLUTION

Spain is a nation of 40.5 million people (as of July 2007) that spends 6.3 percent of its Gross National Product (GNP) on health care (Blendon, Donelan, Jovell, Pellise, & Lombrardía, 1991, p. 216). The life expectancy is slightly higher than the U.S. and its infant mortality rate is slightly lower than the U.S. Through the years, the health care system of the country has developed through five distinct periods into what it currently is today.

- Post war 1939-1966
- Expansion 1967-1975
- Democratization 1976-1981
- First Socialist Gov 1982-1986
- Health Care Reform Initiative Since 1987

Following the Spanish Civil War in 1939, Spain created its first social security system that required mandatory worker contribution. From its inception in 1939 until 1975, 85 percent of the population was covered by this plan (Blendon et al., 1991, p. 217). Through the late 1960s and early 1970s, the government focused on building a strong centralized health care system in urban centers.

With the end of the Franco era in 1975, Spain entered into the democratization period. With that, the Spanish Constitution was accepted in 1978. It provided the right to health protection and health care. With the return of democracy in 1978, the social security system was restructured and renamed the National Institute of Public Health Care (INSALUD). INSALUD remained highly centralized and structured health care system but was unable to meet the regional needs of the local populations. This led to further legislation in the 1986—The General Health Act.

The main principles within the General Health Act were to provide public funding, with universal, free health services at the time of use and the devolution of health affairs to autonomous regional communities. The General Health Act was also designed to allow for the inclusion of different public health structures and services under the National Health System through the creation of the Inter-Territorial Board. The Inter-Territorial Board which is presided over by the Health Minister allows for coordination to occur while still allowing for decentralization of health care. Administratively Spain is organized through 50 provinces, 17 autonomous communities and two autonomous cities, all of which are part of the National Health System Inter-Territorial Board. Today, health care in Spain is a non-contributory benefit paid through taxation. The services provided include health promotion, preventive care, diagnostic and therapeutic techniques, health maintenance and rehabilitation.

B. REPRESENTATIVE EVENT

On March 11, 2004, the day prior to a major election in Spain, four near simultaneous attacks were perpetrated on the commuter trains during the morning rush hour in Madrid; 177 were killed instantaneously and an additional 2062 were injured (Peral-Gutierrez de Ceballos et al., 2005, p. 105). Official reports state that more than 15 public hospitals cared for the 966 people who required care (Peral-Gutierrez de Ceballos et al., 2005, p. 105). In less than three hours, a surge of 272 patients arrived at the Gregorio Maranon University General Hospital (GMUGH) in Madrid, with a total of 212 seeking care from the event (Peral-Gutierrez de Ceballos et al., 2005, p. 105). Of those transported to hospitals to receive care, 14 died subsequently, raising the death toll to 191 (Peral-Gutierrez de Ceballos et al., 2005, p. 105). The critical mortality rate, defined as the death rate among the critical survivors, was 17.2 percent (5/29) (Peral-Gutierrez de Ceballos et al., 2005, p. 105). Critical mortality rate is universally accepted metric to measure the magnitude of a disaster and the outcomes of the medical management of the critically injured.

C. IMPLEMENTATION SUCCESSES AND OPPORTUNITIES FOR IMPROVEMENT

One success noted in the after action review reports was that there were “an abundance of medical teams, nursing staff and resources to treat the critically injured and no critically injured patient experienced a delay in treatment.” It was reported that over 70,000 health professionals rendered care and an astounding 291 ambulances were available to transport victims (Peral-Gutierrez de Ceballos et al., 2005, p. 105). Triage accuracy was cited as an area that needed improvement. As typical during a large scale disaster, “over-triaging” or the inappropriate assignment of non-critically injured victims to the category of critical was determined to be 68 percent (Frykberg, 2005, p. 20). The concern when over-triaging occurs is that limited medical resources will become further overwhelmed with victims who are not the most in need of the resources. However, the critical mortality rate of 17.2 percent appears to be within the expected range and did not appear to be negatively influenced by the high over-triage rate. Important to note was the under-triage rate was determined to be zero indicating that no critically injured victim was over-looked (Peral-Gutierrez de Ceballos et al., 2005, p. 106). This most likely positively influenced the critical mortality rate.

Triage at GMUGH was performed by the most experienced trauma specialists at the entrance of the Emergency Department. Casualty distribution appears to have been handled well. The closest hospital, the Gregorio Maranon University General Hospital, was not overwhelmed with the victims they received. Distribution of victims to the most appropriate surroundings hospitals allowed GMUGH to serve as an initial casualty collection site and maintain capacity for future incoming victims. Post-event commentary cited other important lessons that contributed to the low critical mortality rate including the utilization of damage control procedures.

D. GENERALIZABLE PRACTICES

Elected officials in U.S. wanted to examine what lessons could be learned from the events in Spain. On March 25, 2008, a study was conducted at the request of Representative Henry Waxman in seven key U.S. cities to determine whether any of

these cities could handle a surge of patients like that which was handled in Madrid, Spain on March 11. Cities that were included were New York City, Los Angeles, Washington D.C., Chicago, Houston, Denver and Minneapolis. It was determined that none of these seven cities would have been able to handle the surge of patients as was handled by the one single hospital in Madrid (GMUGH), which was able to handle 272 patients in less than three hours (House Committee, 2008). The hospitals cited three new Medicaid rules that will have an impact in their ability to respond to mass casualty incidents. The hospitals estimated an annual loss of \$623–\$654 million from these changes in the regulations (see Table 2) (House Committee, 2008). These changes to Medicaid combined with the increased population ED visits, which, as previously have noted, between 1996 and 2006 grew from 34.2 to 40.5 per 100 persons, will continue to overwhelm and further debilitate the fragile U.S. emergency medical system (Pitts et al., 2008, p. 2). The Medicaid changes include:

- The Cost Limit for Public Providers Rule (CMS 2258-FC, 29 FR 29748) which narrows the definition of a public provider and limits payments to public providers to the cost of treating Medicaid patients.
- The Payments for Graduate Medical Education (GME) Rule (CMS 2279-P, 72 FR 28930) which prohibits federal matching funds for the cost of GME programs as part of Medicaid reimbursement for inpatient or outpatient services
- The Outpatient Hospital Services Rule (CMS 2213-P, 72 FR 55158) which narrows the scope of Medicaid outpatient hospital services paid on a prospective basis and excludes other outpatient Medicaid services from coverage.

Table 2. Estimated Annual Loss of Federal Medicaid Funds to Level I Trauma Centers by City (in Millions)

City	Cost Limit Rule	GME Rule	Outpatient Hospital Rule	Total Funding
New York City	116	234	35	384
Los Angeles	85	18	2	104
Chicago	25-35	4	1	30-40
Houston	70-81	4	0.2	74-85
Denver	30-40	0.4	NS	30-40
Total Nationwide	326-357	260	38	623-654

Perhaps even more telling were the comments offered by each of the hospitals. Denver Health stated, “The impact of these regulations, if implemented, will be to devastate the Colorado safety net system requiring Colorado’s safety net hospitals to substantially decrease care to the uninsured.” The Ben Taub Hospital in Houston remarked, “The hospital district will have to significantly reduce services to the uninsured and the indigent patients in Harris County in order to bring the cost of services provided in line with funds available.” And University of Southern California Medical Center in Los Angeles added, “The impact of these regulations will undoubtedly result in the reduced inpatient and outpatient services in Los Angeles County. Decreased access will result in further impacts to emergency rooms already overwhelmed by increasing patient volumes”(House Committee, 2008).

One of the primary differences between the Spanish system and the U.S. is unlike Medicare, which is strictly a health insurance program; the Spanish Social Security System developed a highly centralized national health system of hospitals and clinics. Then through decentralized management, the Inter-Territorial Board has been able to provide coordinated and collaborative services to its population. In the U.S., hospitals, unless part of a corporate network, rarely work together to create and sustain regional preparedness. Furthermore, current financial issues as expressed in the Waxman paper restrict adequate hospital preparedness. Hospital preparedness is an additional “unfunded mandate.” As hospitals struggle financially to keep the doors open and maintain everyday

capacity, preparing for something that will more likely not occur is not a priority. Hospitals simply hope a disaster will not happen close to them, so they become the first hospital at which victims arrive.

IV. UNITED KINGDOM

A. HISTORY AND EVOLUTION

There can be no question that the histories of the United States and the United Kingdom are inextricably linked. An amalgam of cultures, the U.S. emerged from a violent revolution, a modified copy of the UK which had spawned it. Over the course of 250 plus years, the countries have endured numerous wars, the death of colonialism, climactic shifts in world power and dramatic changes in population levels, distribution and makeup. Yet for all their differences, these two distant relations still look to each other for support in foreign policy matters. As Britain faces increased homegrown terrorism, the United States watches—relieved it is not occurring in its nation, but knowing intrinsically that the occurrence in the United Kingdom is a prognostication for the future of the U.S. The U.S. must look to the UK as a mentor; to learn lessons which will help it navigate through the coming storm of international and domestic terror. Today the UK and the U.S. share language, culture, governmental structure and democratic processes.

In the 2001 census, the overall population of the UK, which is comprised of England, Scotland, Wales and Northern Ireland, was determined to be close to 59 million. By mid-2008, the population of the UK continued to grow to 60.9 million (Central Intelligence Agency [CIA], 2008). The majority (84 percent) of the UK's populace is located in the densely populated country of England claiming 50.7 million people (as of 2006) (Office for National Statistics, 2007). The UK is a parliamentary democracy with a constitutional Monarch as Head of State and bicameral legislature made up of the House of Lords and the House of Commons. Life expectancy is slightly higher in the UK than the U.S. and its infant mortality rate is slightly lower than the U.S. The overall U.S. life expectancy in 2005 was 77.8 years; female—80.4 years, male—75.2 years (Kung, Hoyert, Xu, & Murphy, 2008, p. 7). The U.S. infant mortality rate in 2005 was 6.87 deaths per 1000 live births (Kung et al., 2008, p. 11). The overall UK life

expectancy in 2008 was 78.85 year; female—81.46 years, male—76.37 years. The UK infant mortality rate in 2008 was 4.93 deaths per 1000 live births (CIA, 2008). This is depicted in Table 3.

Table 3. Life Expectancy & Infant Mortality Rate Comparison between the U.S. & the UK

	Life Expectancy	Female	Male	Infant Mortality
U.S. ⁽²⁰⁰⁵⁾	77.8	80.4	75.2	6.87/1000 live births
UK ⁽²⁰⁰⁸⁾	78.85	81.46	76.37	4.93/1000 live births

The United Kingdom has for a long time had legislation to protect the civilians and address emergency response starting in 1948 with the Civil Defence (sic) Act and the 1950 Civil Defence Act of Northern Ireland. Most recently these acts were updated to recognize and accommodate the ever growing risk within UK society. Thus in 2004, The Civil Contingencies Act (CCA) replaced the Civilian Defence Acts and gave the British federal government expansive authorities concerning civil contingencies and serves as a framework for emergency response during disasters.

The new CCA addresses threats to domestic services that the fore-mentioned acts previously did not. Civil contingencies include the protection of human life, health or safety and the treatment of human illnesses or injuries. The CCA is divided into three parts; Part One—Civil Protection, Part Two—Emergency Powers and Part Three—Supplementary Legislation that support the Act. Part One defines the organizational roles and responsibilities. Part Two defines the temporary emergency powers and regulation that can be assumed by the Queen for a period of up to 21 days.

The U.S. has always valued rugged individualism. As such, the U.S. did not have a comprehensive plan for federal emergency response until 1979 when through executive order the Federal Emergency Management Agency (FEMA) was created. Federal emergency response was further codified with the passage in 1988 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The Stafford Act expanded Federal emergency response giving statutory authority to FEMA.

Many similarities exist between the UK and the U.S. Just as the UK revamped their emergency response contingencies to meet the current threats, the U.S., following the devastation of September 11, 2001, passed the Homeland Security Presidential Directive -5 (HSPD-5) on February 28, 2003. The purpose of HSPD-5 is to enhance the ability of the U.S. to manage domestic incidents through standardized structures, policies and procedures. HSPD-5 promotes inter-operability among all response agencies through the use National Incident Management System (NIMS). Ongoing evolution led to the 2005 National Response Plan (NRP) which defined how the federal government, in times of national incidence, would work in concert with state, local, and tribal governments and the private sector. The NRP was designed to be implemented also using NIMS.

B. REPRESENTATIVE EVENT

On July 7, 2005 at the height of rush hour three nearly simultaneous bombs exploded in the London underground transit system. Occurring at 8:50 am, the first attack occurred between the Aldgate and Liverpool Stations killing seven, followed subsequently within a minute by an attack at the Edgware platform killing six and a third attack occurring approximately two minutes later between the Russell Square and King's Cross St. Pancras Stations resulting in an additional 26 dead. Within 50 seconds three terrorist attacks had claimed the lives of 49 innocent commuters, yet the attack was not over. One remaining terrorist had boarded a double-decker bus. At 9:47 am another 13 lost their lives at Tavistock Square when he detonated himself. In total, 52 victims died at the hands of four extremist Islamic terrorists (for a total of 56 deceased) and 775 were injured, 20 of them critically injured; it was the biggest and deadliest attack ever perpetrated on the London transit system.

In a retrospective analysis of the health care delivered, it was determined that 53 of the 56 deceased, died at the scene. Figure 2 depicts the geographic locations of the attacks.

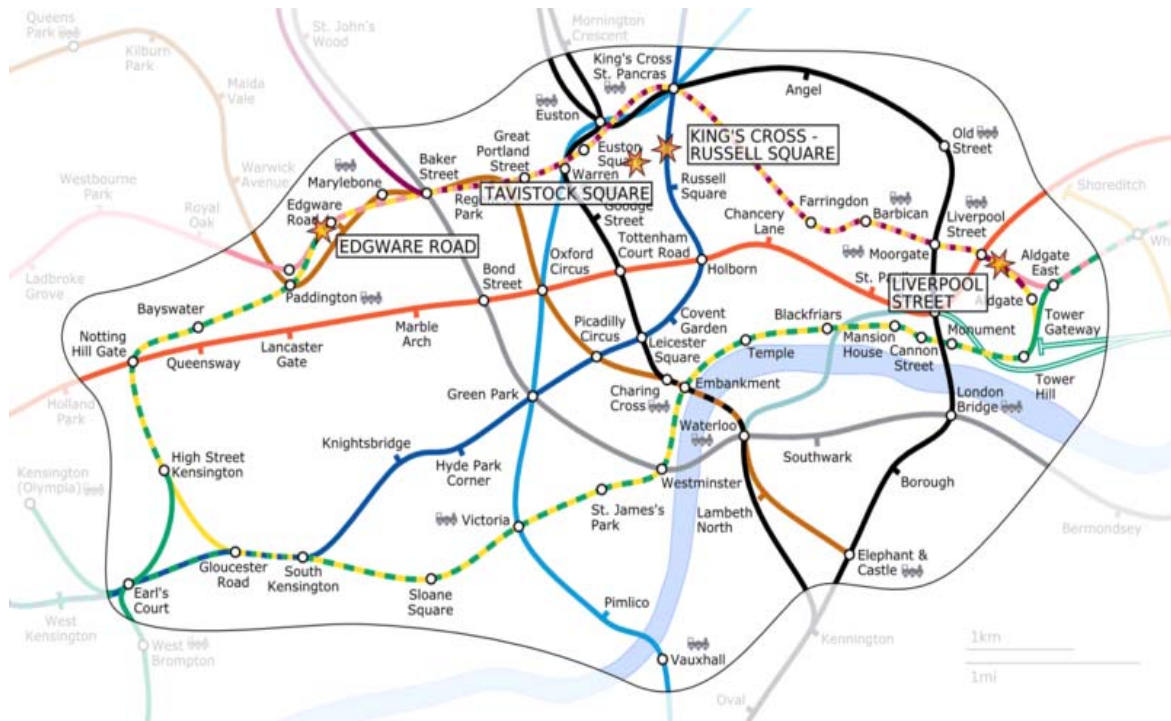


Figure 2. July 7, 2005, London Bombing Locations (From Wikipedia)

Over triage is defined as victims who are triaged as critically injured when they are indeed not. The overall over-triage rate was calculated to be 64 percent. On further analysis of each individual site, the over-triage rates varied greatly from Edgware Road and Tavistock Square where over-triage rates were high and Aldgate and King's Cross/Russell Square where over-triage rates were low. A predominate difference noted was in who completed the triaging at the scene. At both Edgware Road and Tavistock Square the triage was completed predominately by ambulance service and medically trained bystanders. The over-triage rate was 88 percent and 77 percent respectively. Whereas at Aldgate and King's Cross/Russell Square the triage was completed predominately by the Royal London's Helicopter Emergency Medical Service (London-HEMS) and the over-triage rates were significantly lower at 27 percent and 40 percent respectively (Aylwin et al., 2006, p. 2220). Conversely, the three deaths that resulted from the 20 critically injured occurred at the two sites with lower over-triage rate (one at Aldgate and two at King's Cross/Russell Square). Table 4 examines at each of the four

sites with regard to the over-triage percentages, the raw number of critical mortality victims, the time for emergency personnel to clear the scene, and by whom the triage was completed.

Table 4. Site Specific Over-triage Percentages in Relation to Critical Mortality, Time to Clear the Scene and Triage Personnel (From Aylwin et al., 2006, p. 2220)

Site	Over Triage %	Critical Mortality	Time to Clear Scene	Triage Completed by:
Aldgate	27%	n=1	64 mins	London HEMS Staff
Edgware	88%	n=0	81 mins	Ambulance Service and Medically trained by-standers
King's Cross/Russell Square	40%	n=2	108 mins	London HEMS Staff
Tavistock	77%	n=0	81 mins	Ambulance Service and Medically trained by-standers
Overall Average	64%	n=3	83.5 mins	

Immediate mortality associated with bombings is higher when it is either in a confined area or when there is structural collapse. Three of the four explosions in London were in confined spaces. The immediate mortality was seven percent (53/775) (Aylwin et al., 2006, p. 2223). The immediate mortality would have been greater had there been a structural collapse in the tunnels. Fortunately that was not the case, although being underground did hamper communications.

Most time consuming was accessing and extricating the victims because three of the four explosions occurred underground. The time to clear the scenes took 64 minutes at Aldgate, 81 minutes at Edgware, 108 minutes at King's Cross/Russell Square and 81 minutes Tavistock Square (Aylwin et al., 2006, p. 2224). The first responder arrived at Aldgate within nine minutes of the 999 call and the first ambulance within 11 minutes. Emergency services deployed to this site were decisive and rapid (Barnes, 2006, p. 25).

At Edgware, communications appear to have slowed down the response. The first responder to arrive was on site 19 minutes after receiving the call (Barnes, 2006, p. 30). At King's Cross the response time was even slower due to severe communication problems that required physical runners to relay information. It is unclear when the first call was made, but the first responder arrived on scene at 9:14 am, approximately 21 minutes after the explosion. The ambulance arrived at King's Cross at 9:21 am, approximately 28 minutes after the explosion. The Fire Rescue Unit did not arrive, indicating the chaotic nature of the response and the severity of the communication failures. The explosion in this train occurred in the first carriage, which was closest to the Russell Square Station. No calls were received from Russell Square until 9:18 am, 25 minutes after the explosion. By the time the first responder arrived at 9:30am, 37 minutes after the explosion, the conductor was leading the victims to the surface. The first ambulance did arrive until 45 minutes after the explosion at 9:38 am. This was the slowest of the response times (Barnes, 2006, pp. 33-34).

The response at the Tavistock Square bus explosion was considerably faster. The first call was made within seconds of the attack at 9:47 am. Police just happened to be on site. It occurred just across the street from the British Medical Association building which contained physicians and other trained medical providers who were able to help. The first ambulance arrived 10 minutes later at 9:50 am (Barnes, 2006, p. 37).

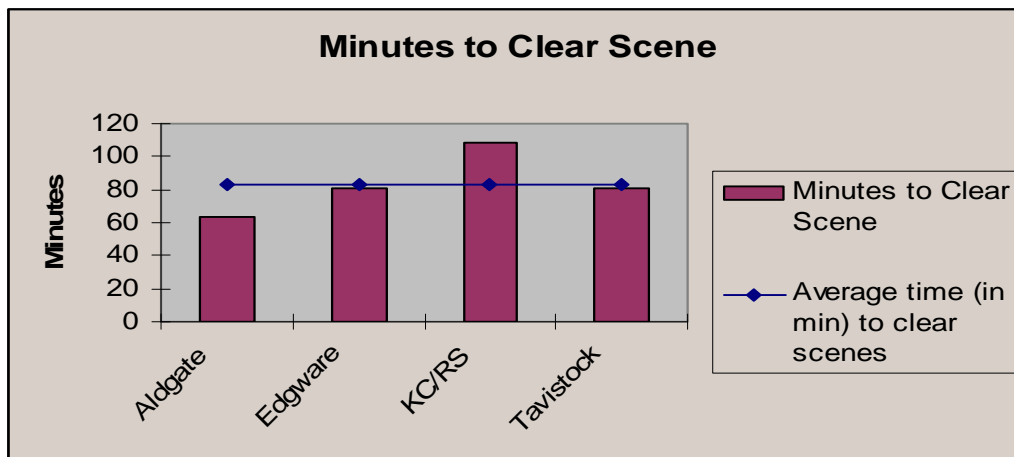


Figure 3. Time to Clear the Four Scenes (From Barnes, 2006, pp. 33-37)

Numerous contributing factors are being examined for the overall incident including; over-triage rates, time to clear the scene, level of experience of the triage personnel and the immediacy of access to trauma care. A fine balance exists between scene clearance and triage accuracy. With increased speed comes decreased triage accuracy and conversely, with decreased speed comes increased triage accuracy but delayed time to access trauma care. Although the events on July 7 were incredibly devastating, the sample size may not be large enough to make judgments about causality with a high level of confidence. However, associations and correlations have been explored. Figure 3 pictorially represents that with each underground bombing the time to clear the scene got increasingly longer from 64 minutes at Aldgate to 81 minutes at Edgware to 108 minutes at King's Cross/Russell Square. The average time it took to clear all four scenes was 83.5 minutes. The first three attacks happened only minutes apart and this perhaps represents the mounting confusion, the break down in communication systems and the stretching of emergency resources. The bombing at Tavistock was nearly an hour after the first bombing, occurred above ground and serendipitously occurred in front of a building containing medical providers and police officers who were able to rapidly initiate the emergency response system. Ambulances that had been dispatched to Russell Square came across the explosion at Tavistock and inadvertently redirected themselves from Russell Square to Tavistock. No critical mortality deaths occurred at Tavistock. These multitudes of factors may have contributed beneficially to the critical mortality rate.

Critical mortality deaths occurred at Aldgate (n=1) and King's Cross/Russell Square (KC/RS) (n=2). Aldgate had the fastest scene clearance yet still had one critical mortality death. Yet, the documented over-triage rate at Aldgate was the lowest at 27 percent. This is credited to the caliber of highly qualified trauma personnel responsible for the triage. Both Aldgate and King's Crossing the triage was completed by the by Royal London's Helicopter Emergency Medical Service (London-HEMS). Perhaps what is being detected at Aldgate was under-triage occurring; indicating that a critically injured person was not identified as such and was not assigned to immediate care. It is felt that a 50 percent over-triage rate is optimal to eliminate under-triage rates and improve triage

accuracy and thus critical mortality rates (Fryberg & Tepas, 1988, p.569). The low over-triage rates of 27 percent at Aldgate and 40 percent King's Cross/Russell Square may have resulted in unintentional under-triage.

The first hour after a traumatic event is referred to as "the golden hour". Although there is no scientifically proven window of time, it is strongly believed in the medical community that the sooner a victim can get to definitive care the greater are his or her chances of survival. The response until all the victims were cleared at King's Crossing/Russell Square was the longest of the disaster at 108 minutes -one point eight hours. This is significantly in excessive of the golden hour. It was unable to be determined in the literature review the percentage of the victims evacuated within the golden hour. The excessive delay to clear the scene possibly negatively contributed to the critical mortality rate at King's Crossing/Russell Square.

C. IMPLEMENTATION SUCCESSES AND OPPORTUNITIES FOR IMPROVEMENT

The bombings on 7-7 had a lower critical mortality rate (15 percent) in relation to other terrorist mass casualty events. Using historical knowledge from other events, an over triage of 64 percent would be extrapolated to a critical mortality of 25-30 percent (Aylwin et al., 2006, p. 2224). Examining the low critical mortality rate of 15 percent (3/20 that were critically injured) despite the over-triage rate of 64 percent, several factors are believed to have contributed favorably. Credited are the rapid casualty access, assessment and evacuation by an effective pre-hospital trauma system (Aylwin et al., 2006, p. 2223). London's major incident plan requires medical doctors to be present at the scene of an incident to tactically manage the medical component of the response and this was accomplished at two of the four sites (Aldgate and King's Cross/Russell Square). Incidentally, both Aldgate and King's Crossing had a larger percentage of critically injured victims at these two sites (Aylwin et al., 2006, p. 2221). Having scene clearance done in an organized and efficient manner by trained and qualified medical personnel facilitates reduced triage errors. Although a total of three critically injured people died

from these two sites, it can be assumed that more would have died had it not been for the trauma personnel who had the experience to make the critical decisions at the site.

Additionally, critically mortality is also reduced the more immediate the access to health care. The 675-bed Royal London Hospital primary trauma center was fortuitously located between the Aldgate and King's Cross/Russell Square stations allowing for rapid transport to the facility. Being a leading UK primary trauma center, the hospital was specialized in the treatment of patients with acute and life threatening trauma injuries. Primary Trauma Centers require trauma surgeons to be on staff 24-hours a day thus trained and skilled trauma personnel were on-duty and ready to perform as this series of disasters unfolded.

Also credited were the immediate operations done in the "damage control" mode to expand the immediate resources to as many casualties as possible. Surgeries were done only to stabilize the victims rather than to provide all needed definitive care. This allowed the trauma center to optimize its surge capacity and provide life-saving care as quickly to as many people as possible. Subsequent surgeries were scheduled to occur after all the expected casualties had arrived or they were sent to other facilities. Hospital surge was able to be maintained for the duration of the event.

D. GENERALIZABLE PRACTICES

The events that occurred on July 7 teach emergency trauma professionals that reducing critical mortality and improving survival requires ongoing, detailed examination of the trauma health care system and the continual triaging of the victims. Simply dumping a lot of capacity into the system will not reduce critical mortality. Optimized surge capacity requires the system to be able to flex and retract as it needs to. The entire system cannot and does not need to flex at the same time, but rather it needs to pulse as is needed. Systematic reassessment and reprioritization is necessary to optimize surge capacity and needs to occur continually throughout the system to allow resources to be allocated in the way most beneficial at the moment needed. For this to happen at the most efficient level, highly qualified trauma personnel must be involved in this process from

the initial scene and at every step in the process. Trauma personnel cannot be sequestered only in the operating rooms. They need to be forward in the field making the critical decisions in a timely fashion.

Undoubtedly triage errors will occur. Simply because a victim is either over-triaged or under-triaged initially does not mean that triage error needs to continue throughout the system. Having the most highly trained professionals reassessing patients continually allows for the victim to be reclassified; thus surge can be managed appropriately and resources optimized. Accurate triage is known to increase survival (Fryberg & Tepas, 1988, p. 569).

Research indicates that excessive over-triage results in the loss of salvageable lives, and that a linear relationship exists between over-triage and critical mortality (Fryberg & Tepas, 1988, pp. 573–577; Aylwin et al., 2006, p. 2221). One way to manage over-triage is to make certain the initial triaging is conducted by experienced trauma specialists at the disaster site and not at the hospital or by less experienced responders at the scene. Triage can then serve as an aggressive screening tool that allows only the critically injured transport to the hospitals. Less critically injured can be medically managed and continually evaluated away from the hospitals allowing the constrained resources to be used for those most in need.

Optimizing casualty triage and reducing critical mortality is an art and requires an intricate understanding of the forces at play. Rapid scene clearance, although ideal for getting victims to care sooner, can increase under-triage. Under-triage is particularly important to eliminate since it is always life threatening to the victim. Inadvertently overlooking a victim in critical condition robs him of the immediate care he needs. Over-triaging can reduce under-triage rates, but excessive over-triage rates are known to increase critical mortality rates. It is not until after a disaster is over when retrospective review of the medical process determines the over-triage rates.

V. ISRAEL

A. HISTORY AND EVOLUTION

Israel is a nation small in size and in population, its size most often compared to that of the State of Rhode Island. The country has had substantial population growth since the founding of the nation state in May 1948. With only 806,000 residents in 1948, the population of Israel in 2008 has grown to be 7.3 million people—75.5 percent Jewish, 20.1 percent Arab Israelis, and 4.4 percent unregistered (Jewish Virtual Library, 2009). Due to the limited geography, Israel is densely populated at 315 people/square foot (Jewish Virtual Library, 2009). Ninety-two percent of Israelis dwell in urban centers in the largest cities including Jerusalem, Tel-Aviv, Haifa and Rishon Lezion (Jewish Virtual Library, 2009).

Israel is considered the homeland of the Jewish people. Nestled next to the Mediterranean Sea it is surrounded by groups on all sides listed on the U.S. State Department's List of Foreign Terrorist Organizations. Israel is unfortunately no stranger to terrorism. Although there are many dissimilarities between the U.S. and Israel, a lot can be learned by examining closely Israel's emergency medical system and the way it addresses the trauma that besieges it daily.

Like the U.S., Israel has a democratic government. It is governed by a parliamentary system. The Knesset, or legislative branch, consists of 120 elected members who serve for four-year terms. The Knesset would be most similar to the U.S. Congress. The executive branch is headed by the elected Prime Minister. This position is also for a term of four years and would be most similar to the U.S. President. The third branch is the judicial branch and the court system. This, too, is similar to the U.S. Supreme Court and U.S. court system. A fourth position, not specifically seen in the U.S., is the titular position of President. The President is not a member of any of the three branches. The duties of this position are mainly ceremonial. The U.S. President duties are

both that of the executor and to attend ceremonial events (Israel Science and Technology, 2009). Local government in Israel is similar to that of the U.S. Through regional elections, mayors and city councils are elected to manage the cities.

The discipline of emergency medicine (EM) in Israel has, from sheer necessity, grown from its environment. Prior to the early 1990s, EM in Israel was similar to what is found in the U.S. today. The emergency departments were sorely understaffed. Staff coverage was from a myriad of disciplines and 24 hour emergency coverage was limited. However, the first Gulf War in 1991 highlighted the gaping holes in Israel's delivery of EM triggering a wholesale overhaul of the discipline of EM.

In 1993, the National Trauma System was created. Six facilities were designated to become Level I Trauma Centers and an additional 12 were designated to become Level II Trauma Centers. It was decided by the Israel Association for Trauma Medicine that the emergency departments (ED) in these hospitals would be staffed exclusively by trauma surgeons. By 1994, EDs were being redesigned to handle mass casualty events and ED staff was being replaced by certified emergency physicians (Halpern, Waisman, & Steiner, 2004, p. 534).

By 1999, the standards for EM were tightened. EM was recognized as a "super-specialty" rather than a primary specialty, as it is in the U.S. and UK. To practice EM, physicians needed to be board certified in a selective sub-section of specialties then complete an additional two and a half-year residency in EM. Only 63 of the existing emergency physicians met the criteria and were entered into the new super-specialty. Today, Israel has seven training programs that produce a total of 16 graduates a year (Halpern et al., 2004, p. 534). The needs of Israel mandated that their EM physicians be both mature and clinically experienced. Today 27 hospitals in Israel provide emergency medicine services (Halpern et al., 2004, p. 534).

Since 1950, the Magen David Adom's (Red Shield of David) has been the national emergency pre-hospital medical service of Israel operating several levels of response vehicles. It has grown from its modest beginnings in 1930 as a group of volunteers in Tel-Aviv. Magen David is responsible for the nation's blood supply, pre-

hospital services, first aide, transportation of patients and transportation of medical teams. Magen David also can be activated as an auxiliary arm to the Israeli Defense Force during times of War. Magen David is staffed with both paid professionals (600 EMTs and 450 paramedics and a considerable volunteer force numbering over 10,000) (Ellis & Sorene, 2008, pp. 6–8). Physicians who work with Magen David primarily do so as an adjunct to another full-time position. Physicians are from acute hospital specialties, but they are not from the “super-specialty” of EM.

B. REPRESENTATIVE EVENT

In the slightly over 60 years of statehood, Israel has suffered numerous terrorist attacks. They have become such a common occurrence in this small country, its population lives at a level of vigilance which is uncommon in other democratic societies. With all the tragedy that has befallen this small country, Israel’s medical community has the unfortunate reality that makes it a world leader in trauma medicine.

Obviously many individual incidents could be analyzed as a representative event, but with such a collection of occurrences, a retrospective analysis of numerous events provides for more robust statistics. A retrospective review of mass-causality events in Israel from October 1, 2000 to September 1, 2004 was conducted by Aschkenasy-Steuer et al. During this period, 93 mass-casualty events occurred in Israel of which 33 occurred in the city of Jerusalem. The study looked specifically at the events that occurred in Jerusalem and were handled by Hadassah Hebrew University Medical Center, the sole Level 1 Trauma Center in Jerusalem. The study reviewed 541 victims who presented to the emergency department of which 208 were admitted. Overall mortality was measured to be a low 8.5 percent (Aschkenasy-Steuer et al., 2005, 491).

Triage accuracy is central in Israel’s low critical mortality rates. Rather than being held in reserve, trauma specialists (surgeons and anesthesiologists) are forward deployed to the trauma bays to initiate triage immediately upon arrival of a patient. Forward deployment of the most knowledgeable trauma personnel is the standard operating

procedure in Israel and at Haddasah Medical Center. Additionally, command and control is established immediately and the position of commander is given to the most senior trauma personnel present.

Additionally, the authors of this study credit Israel's unidirectional flow philosophy. Victims flow is in one direction only. Once the victim leaves the emergency department, they are not brought back. This allows for more timely assessment of all the victims. Another unique feature of the Israeli emergency medical system is that they have instituted scoop and run. Cognizant of the dangers of secondary explosions and terrorist attempts to collaterally damage the emergency medical system, little if any triage is done at the scene. The victims are rapidly extricated from the field and brought to the trauma team.

C. IMPLEMENTATION SUCCESSES AND OPPORTUNITIES FOR IMPROVEMENT

The scope and role of the paramedic has grown substantially. In the U.S., paramedics start intravenous (I.V.) lines and initiate not only Basic Life Support (BLS), but also Advanced Life Support (ALS). The Israeli emergency medical system has elected to minimize pre-hospital medical interventions. Rather than have paramedics stabilize and provide care in the field, they employ scoop and run (S&R) techniques. The alternate philosophy, when the victim is stabilized in the field, is referred to as stay and play (S&P). Because definitive medical care and equipment are not available in the field, it is felt that pre-hospital interventions delay the time it takes the victim to reach definitive care thus resulting in diminished outcomes.

The benefits of scoop and run need to be compared in relation to the transport time. Israel is unique in that its population is concentrated in very urban settings close to its hospitals. In 80 percent of the transports, the response time is within 10 minutes and in 95 percent of the transports, the response time is within 15 minutes (Rivkind, 2008). This must then be compared to the length of time it takes to provide pre-hospital procedures and whether that time is well invested in improving the clinical outcome of the victim. The insertion of a peripheral I.V. line takes eight to 12 minutes depending on the

experience of the technician (Rivkind, 2008). If the victim is in need of damage control surgery to stop severe blood loss and the transport time is less than the time it takes to complete the pre-hospital intervention, then scoop and run techniques may be in the better interest of the patient, particularly if the administration of fluids cannot be made at the same rate in which blood is being lost and the victims is at risk for exsanguination.

Scoop and run is favored over stay and play (S&P) when the injury is penetrating in nature. In a retrospective study of 180 trauma victims conducted at the Level I Trauma Center at Temple University, it was determined that pre-hospital procedures reduced survival rates in trauma victims with penetrating injuries (Seamon et al., 2007, p. 119). Penetrating injuries are also the type most often seen in civilian terrorist bombings as a result of secondary blast injuries caused primarily by flying shrapnel and tertiary blast injuries caused when the blast wind either throws the victim against a fixed surface or a solid object strikes the victim (Seamon, 2007, p. 119; Davis & Lee, 2004). The study demonstrated that each pre-hospital procedure prolonged transport time to definitive care and pre-hospital procedures being done by paramedics were not the most critical intervention that was needed for a hypovolemic victim who had suffered penetrating injuries. Scoop and run techniques run the risk of increasing over-triage rates since everyone is being brought to the trauma bay rather than being sorted at the scene. Israel addresses this by placing their trauma surgeons and anesthesiologists in the trauma bays.

D. GENERALIZABLE PRACTICES

Like Israel, the U.S. emergency medical system today generally uses scoop and run principles; moving a victim as soon as it is safe to do so. The current goal is to get a patient transported within 10 minutes. Much is written in the literature concerning the relative benefits of S&R verses S&P. Despite fervently written polemic articles from both sides, it is important to understand the instances and factors that make one approach better than the other. The U.S., UK and Israel use scoop and run whereas most of Europe, including France and Germany, use stay and play (Seferin, 1998). Why has Israel elected

to use scoop and run and why does this system appear to work favorably for them considering the retrospective review by Aschkenasy-Steuer et al. measured overall mortality to be only 8.5 percent (Aschkenasy-Steuer et al., 2005, p. 491)?

As with much in medicine, a sequential algorithm can help identify critical information to facilitate the decision process necessary to improve outcomes. Understanding the factors that improve survivability based on the injury types sustained and the environment the care is being rendered in can improve survivability. Each emergency medical system needs to make the determination based on their unique factors. Scoop and run is a favorable system when the response time to definitive care is fast. For that reason, scoop and run works well in an urban population where both population and hospitals are clustered. In a rural setting or in a situation where the time to get to definitive care is extended, pre-hospital stabilizing is required and this is done through stay and play.

Likewise, the greater the percentage of penetrating injuries, the more favorable is scoop and run. When knife stabbings or gun shot injuries are prevalent, scoop and run will be favored. Communities, such as Israel, who respond routinely to the penetrating injuries associated with bombings will favor scoop and run. Communities that have fewer penetrating injuries will be more inclined to use stay and play, particularly if their ambulances are staffed with physicians and equipped with more advanced supplies.

Additionally, the professional types that staff the ambulance can affect the decision. In the U.S., physicians are rarely seen providing care interventions in a pre-hospital setting. Whereas in countries that use stay and play, such as Germany, physicians routinely respond pre-hospital. Israel's system is a hybrid. Magen David operates several levels of ambulance. The EMT-B (basic) is staffed with either two EMTs or one EMT and one volunteer and contain basic equipment and defibrillator. They are primarily used for patient transport. They contain no physicians. An intermediary intensive care ambulance is staffed with one paramedic and one EMT. The intermediary ambulance also contains no physician. The Mobile Intensive Care Unit (MICU) is the highest level ambulance. It does contain a physician along with one paramedic and one EMT who usually serves as the driver. The MICUs are equipped to care for more critical patients.

The following algorithm in Figure 4 delineates the factors that need to be considered in the pre-hospital environment when determining whether scoop and run or stay and play is the better process for the population being served.

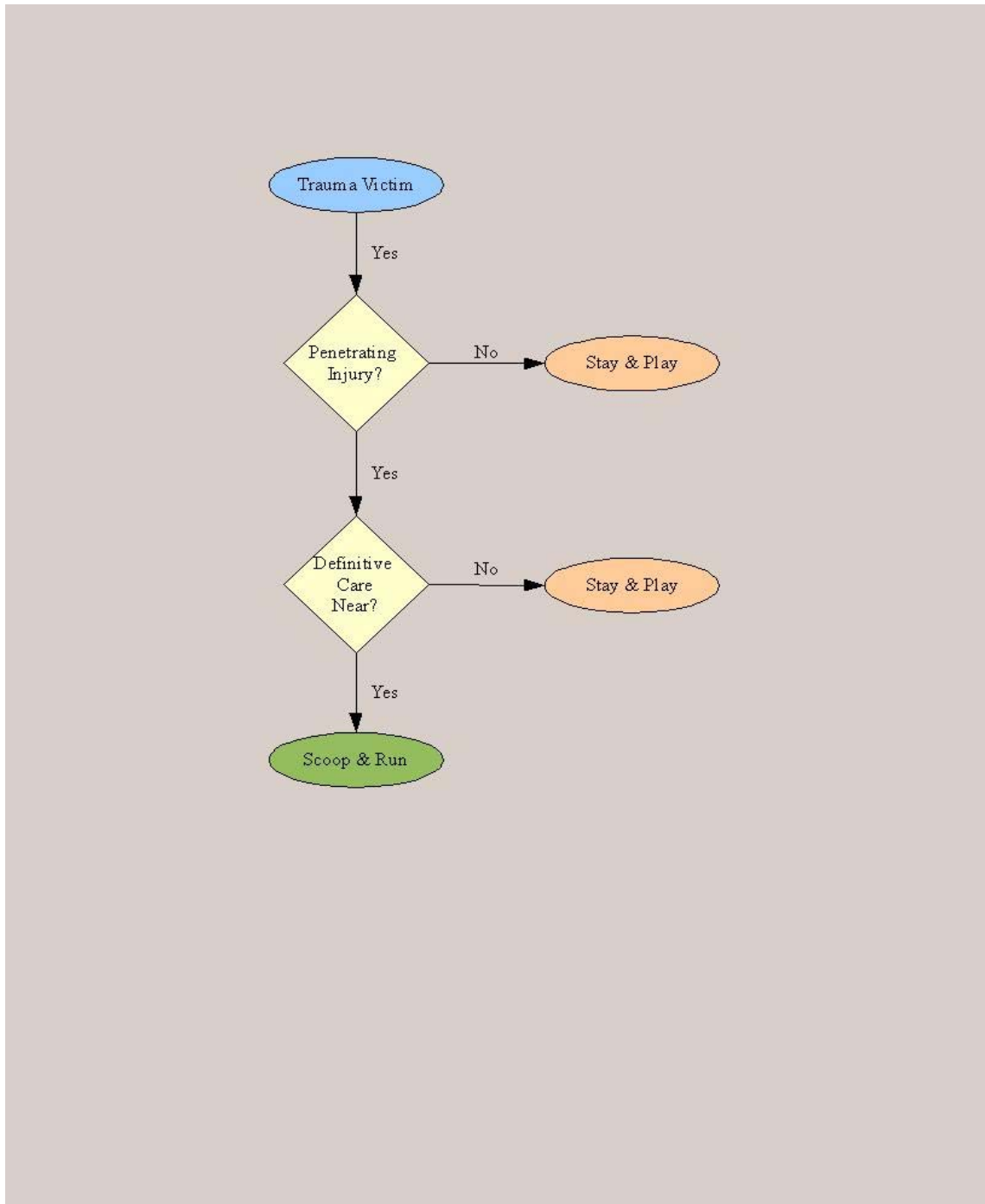


Figure 4. Algorithm for Determining Pre-Hospital Procedures

Predominate differences between scoop and run and stay and play are detailed in Table 5 below.

Table 5. Predominate Differences between Scoop and Run and Stay and Play

	Scoop and Run	Stay and Play
Countries Utilizing	Israel, U.S., UK	Germany, France
Medical Lead	Paramedic	Physician
Philosophy	Transport to definitive care under 10 minutes	Stabilize first, then transport
More ideal Environment	Urban Setting : population and hospitals are clustered	Rural Setting: population and hospitals are spread apart
Use of Ambulance	For speedy transport	Serves as “hospital on wheels”

Israel has demonstrated a low overall mortality rate in the victims cared for during the Second Intifada at Haddasah University. The favorable outcomes for the victims are a result of numerous aggressive changes Israel has made since the early 1990s. In addition to using scoop and run techniques to expedite transport to definitive care, Israel has forwardly deployed its most experienced trauma surgeons to the emergency bays to improve triage accuracy and to maintain continuity of care. Understanding that a large majority of survivors are not critically injured and that the non-critically injured are usually the first to reach the hospital, Israel has developed a system that reduces over-triage rates by having their most qualified complete the initial triage (Frykberg & Tepas, 1988, p. 569).

The specialty of emergency medicine has evolved out of necessity to be a super-specialty, ensuring the maturity and years of experience necessary for a physician to perform in these critical situations. In addition to providing triage, an EM physician also serves as the incident commander maintaining detailed records and tracking the placement and disposition of each victim. To maintain capacity, victims flow through the

system in only one direction. Once they move through the ED, they are not returned to the ED. The capacity of the ED is reserved for additional victims who are being brought to the hospital.

ED staff in Israel understands the epidemiological differences of terrorist bombings. They have extensive experiential clinical understanding of the major injury differences between a confined space explosion and an open spaced explosion, allowing them to be more clinically prepared when victims come through their doors. Israel has identified that from the time of an attack, they have approximately 20 minutes before they receive victims. In those few minutes an assessment of the size and severity of the incident occurs. Based on the day of the week and the time of the day, and the location of the blast they can estimate roughly the number of victims to expect and the severity of their condition. Explosions in confined areas result in more severely injured victims. Additional staff is recalled to the hospital. Communications are established immediately with the emergency medical service for up to the moment casualty reports. By addressing all of these factors, Israel has improved its trauma care dramatically.

Lessons learned in Israel should be examined for applicability in other health care systems as appropriate. The U.S. has had the luxury of having very few terrorist attacks on its soil. With that luxury comes inexperience in handling these situations. In addition, the rarity of the events can create complacency and an unfortunate expectation that what other nations are experiencing will not ever happen in the U.S. Israel's trauma system evolved not so much because it wanted to but because it had to. Israel's maturation over the past 15 years is resulting in improved outcomes and saved lives after terrorist attacks. Although there are numerous differences between the U.S. and Israel, salient components can be examined for consideration and implementation in the U.S. trauma delivery system.

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VI. U.S. MILITARY

A. HISTORY

Tactical field care during war has given the United States military ample opportunity to develop combat trauma guidelines that serve and protect the casualty / soldier to the greatest extent possible. Prior to the mid-1990s, military trauma care followed that of the civilian world. In 1996, understanding that the military faces environmental challenges that are very different from the civilian world, the Tactical Combat Casualty Care (TCCC or TC³) treatment guidelines for casualties in the battle field were developed by the U.S. Special Operations Command (USSOCOMM). These guidelines have been implemented in Special Operations Units and have been endorsed by the National Association of Emergency Medical Technicians (EMTs) and the American College of Surgeons and are being used in the most current wars in Iraq and Afghanistan. TCCC is considered to be both a medical and logistical model. The goal is to meet the best outcomes for the casualty and the mission. The premise for TCCC is that the care is tiered, constituting tactical actions carefully designed to yield the greatest decrease of preventable combat death. Casualty care must be critically executed and appropriately timed corresponding to the tier.

Due to the nature of war, the provider has little if any knowledge of the victim, pre-existing health conditions or documentation of previous health care. The duty of the military medical provider is to the mission. Thus the triage paradigm is shifted. Rather than rendering care to the worst scenario first, triage is rank-ordered based on survivability. Priority is given to the soldier who has survivable injuries over the soldier that has non-salvageable injuries. Injuries that are considered to be non-salvageable include mortal wounds, 100 percent full-thickness burns, blunt traumatic cardiac arrest, cardiac arrest from chemical, biological, radiological, nuclear, and explosive events (CBRNE), trunk trans-section, head penetration that affects both hemispheres, blast lung and total body disruption (Davis & Lee, 2004).

B. REPRESENTATIVE EVENT

According to statistics from the Department of Defense, the lethality of war has decreased significantly since the Revolutionary War. In 1783 following the Revolutionary War, the lethality of the war wounded was 42 percent. In the current war in Iraq, the lethality of the war wounded has dropped to 10 percent. Of course a lot has changed both in the waging of war and the practice of trauma medicine since 1783. However, this is a significant reduction and one that warrants examination, particularly the implementation of TCCC.

During the first Iraq War in 1990–1991, TCCC guideline had not yet been put into practice. The lethality from the first Persian Gulf War in Iraq was 24 percent. TCCC guidelines were implemented in 1996 between the first Iraq War and the current war. The lethality of the current war has dropped significantly to 10 percent (as calculated in 2004) (Gawande, 2004, p. 2472). As shown in Figure 5, the lethality during the Korean War, Vietnam, and the Persian Gulf War remained relatively constant, around 24 percent; therefore, a drop to 10 percent is a marked decrease. Even if one examines the linear trend of the percentage of lethal war wounds over sequential military actions, the current lethality is still far lower than the estimated trends. TCCC guidelines have been credited in part to this significant improvement.

Although other contributing factors may be influencing the decrease in lethality, the implementation of TCCC guidelines is viewed as an “overwhelming success” according to CPT Michael Tarpey, Battalion Surgeon for the 1/15th Infantry (Butler, 2005, p. 3). The TCCC initiative is now being implemented in other medical units including the 82nd Airborne, the 10th Mountain, the Third Infantry, and the 101st Airborne Divisions (Butler, 2005, p. 3).

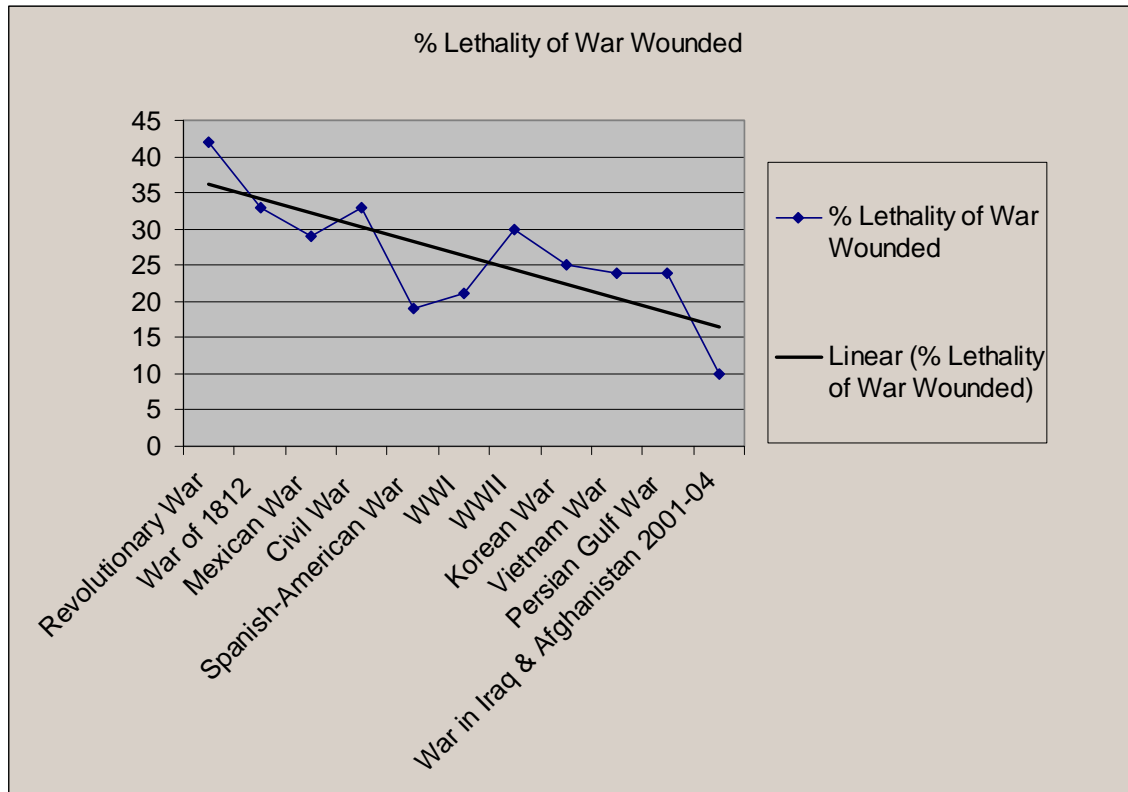


Figure 5. Percentage of Lethality of War Wounded (From Gawande, 2004, p. 2472)

C. TCCC DEFINITION AND IMPLEMENTATION

TCCC is focused primarily and specifically on the epidemiology of combat injuries most often encountered in war. The military understands that 90 percent of combat deaths occur in action (KIA) on the battlefield. As such, it has identified the injury types not sustainable for life, allowing it to redirect efforts to provide the highest survivability for those soldiers that are not killed (Tarpey, 2005). The emphasis has been changed to address the most common battle field injuries.

Important to highlight are the difference between conventional civilian emergency care and the treatment of battlefield casualties. The conventional civilian emergency standard of care rendered is to provide all care necessary to a single patient by multiple staff with specialty staff as back ups and unlimited resources. Conventional emergency room practices revolve around advanced life support (ALS). ALS follows the convention

known as A-B-C-D, where A stands for assess airway, B for breaths or ventilation, C for circulation or chest compressions and D for definitive care, defibrillation, and drugs. TCCC guidelines do not follow the ABCD algorithm of ALS. TCCC avoids teaching procedures such as Cardio-Pulmonary Resuscitation (CPR) and endotracheal intubation since they have not proven valuable in combat medicine. Reviving an individual following traumatic cardiac arrest has a bleak prognosis. CPR was developed for hearts in otherwise healthy people and even then the survival rate is lower than five percent (Stiell, 2004, p. 647). Therefore A (airway) and the B (breathing) are not done in the field. The algorithm starts with C (circulation or hemodynamics). TCCC follows a C-B-A algorithm while conventional emergency room care follows the A-B-C-D paradigm.

The overwhelming cause of preventable death remains hemorrhaging from extremity injuries. Understanding that rapid hemorrhaging leads to death, tourniquets are used until the casualty can be moved to emergent surgery and definitive care. TCCC focuses on training medics to stop hemorrhaging promptly. TCCC guidelines have proven to save lives by stopping hemorrhaging. -In an After Action Review (AAR) of the medics of the 75th Ranger Regiment, it was noted that at least seven Ranger's lives had been saved through the use of tourniquets (Butler, 2005, p. 3). Furthermore, in a retrospective study conducted on the deaths of 84 Special Operations troops in the current war, it was determined that 12 (14.3 percent) of those deaths may have been preventable had the TCCC guidelines been adhered to more closely (Butler, 2005, p. 3). Once the lifesaving intervention is made, rapid evacuation of the casualty to a forward surgical team (FST) is imperative.

Military surgery and TCCC aim for damage control. Damage control surgery is a major advance in trauma medicine, but it requires a paradigm shift from traditional surgery techniques and teachings that favor definitive surgery. TCCC understands that patients with massive exsanguinating injuries will not survive complex and extensive procedures. Therefore the surgery is staged using damage control procedures. Patients are moved through the battle theater care accordingly. The first step is to stop hemorrhaging and control contamination. This is done at the FST.

The FST is a new concept in the military medical operation; its genesis from lessons learned during Operation Desert Storm/ Persian Gulf War where lives were lost unnecessarily from blood loss. The FST was initially created in 1997 to move just behind the troops and provide the first level of trauma care. The FST concept was adopted and now more than 10 teams are operating in Iraq. Being mobile allows the casualty to be within 60 minutes of the FST. The capabilities of the FST include supplies to conduct surgery, including anesthesia equipment, an intensive care pack and ventilators. The team is comprised of 20 people: three general surgeons, one orthopedic surgeon, three nurses, the remainder medics and ancillary personnel (Gawande, 2004, p. 2471).

Surgery that occurs at the FST is not definitive but rather done using the damage control procedures. Surgeries are reduced to be less than two hours in length. Emphasis is simply to stop the hemorrhaging and to control contamination. From the FST, victims are med-evaced to the next level of care often with the wound open, still sedated, paralyzed and ventilated to the combat support hospital (CSH).

CSHs are located further from the battlefield but still within the theatre of operation. The mission of the CSH is to provide medical care and hospitalization services in support of combat operations. Here as well as at the FST, the care is not meant to be definitive. The maximum length of stay is meant to be no more than three days. Patients who require more than three days are transferred to a level IV hospital. These are located in Germany, Spain and Kuwait. If it is anticipated a soldier will require more than 30 days of treatment, he or she is further med-evaced back to the United States where he or she is either treated at Walter Reed Army Medical Center in Washington, D.C. or the Brooke Army Medical Center in San Antonio, Texas. Figure 6 demonstrates the rapid movement of the victim in concentric circles outward from the battlefield toward definitive care.

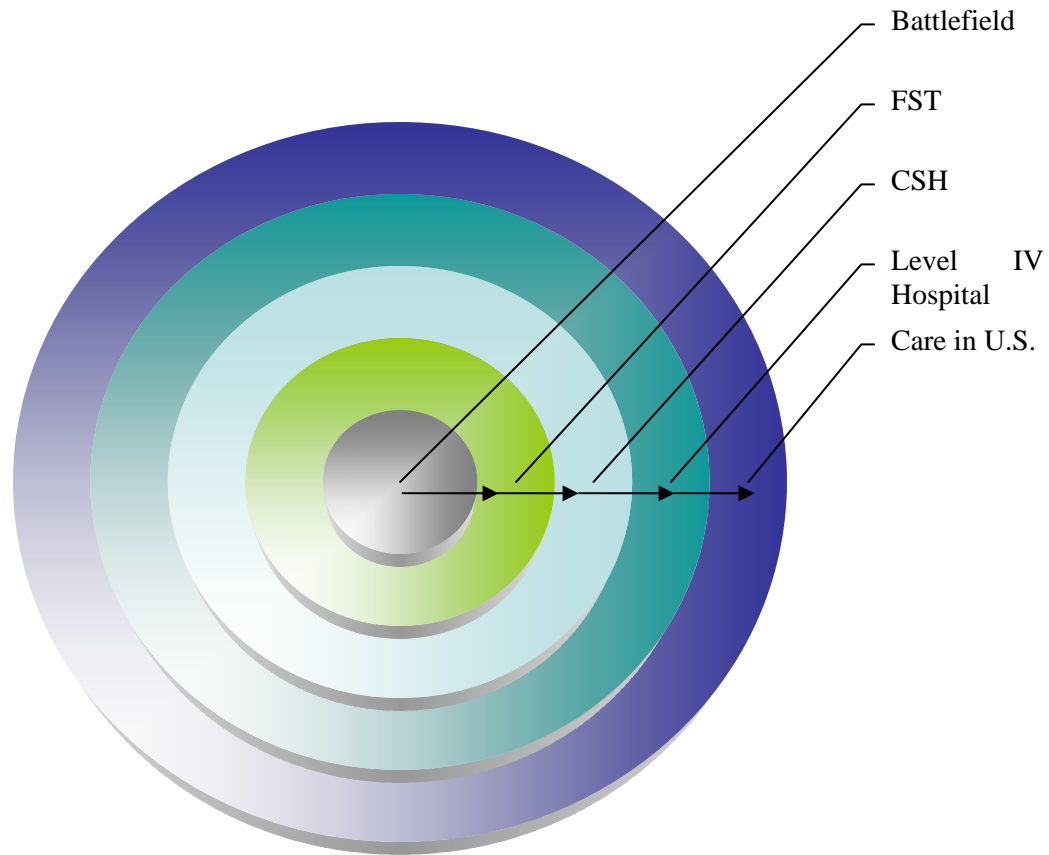


Figure 6. Casualty Movement from the Battlefield through Centric Levels of Definitive Care

Change is difficult for humans to make—particularly when a provider is trained and practices for years to provide the best definitive care possible. It is the antithesis of “good medicine” to complete only part of a procedure and put the patient on a helicopter for someone else to finish up the work. Initially, surgeons were reluctant to give up “their patients” and wanted to hold onto their patients to provide definitive care. However, the wisdom of the system has slowly transformed combat medical operations. According to reports from Walter Reed Army Medical Center, at the beginning of the war in May 2003, it took on-average an injured soldier eight days to be moved from the battle field to definitive care in the United States. By late 2004, the average time was reduced to less than four days. Compared with the Vietnam War when it was 45 days, this is significant

improvement (Gawande, 2004, p. 2473). As surgeons have embraced the principle of TCCC and damage control surgery, casualties are moving to the appropriate level of care where they can receive definitive care more quickly. Although it may be too soon to make a definitive assertion, the fundamental changes implemented between the first Persian Gulf War and the current war appear to be strongly correlated to the reduction in lethality between the two wars.

Challenges do exist with the implementation of TCCC. Physicians, medical staff and medics that routinely work in a civilian emergency room need to continually receive the latest training in the TCCC guidelines. It has been determined that the closer the medics/medical providers receive this training to when they are actually deployed to the field, the better they perform in the combat environment (Butler, 2005, pp. 1–6). Additionally, medics must be specifically trained to use the medical equipment and implement medical procedures most common to combat trauma. These include, but are not limited to, tourniquets, application of hemostatic agents and hypotensive resuscitation.

D. GENERALIZABLE PRACTICES

During a civilian mass casualty event, particularly involving explosives, it is imperative to accept and recognize that the medical environment will be more similar to the battle field than to a routine day in the emergency room. Rather than predominately blunt traumas, injuries will be more in-line with those seen on the battlefield. In the case of a bombing, the characteristics of the bomb significantly change the anticipated impact. The types and frequencies of injuries are categorized into four major categories. These include *Primary*, *Secondary*, *Tertiary*, and *Quaternary Blast Injury* (Arnold, 2003, p. 223). Table 6 delineates the characteristics of these blast injuries.

Table 6. Characteristics of Blast Injuries

	Primary	Secondary	Tertiary	Quaternary
Cause	Barotrauma of the explosion	Flying shrapnel	Blast wind—victim thrown against a fixed surface or a solid object strikes victim	Fire or structural collapse
Injury Types	Blast lung syndrome, Tympanic membrane rupture, Intestinal perforation	Soft tissue injuries	Impalement, Traumatic amputations,	Smoke inhalation Burn injuries
Setting	Confined space	Open air		
Immediate Mortality	4% (1-11%)(Arnold, 2003, p. 220)	1% (0-5%)(Arnold, 2003, p. 225)		

Epidemiological outcomes vary greatly with the characteristics of the event. This is specifically why civilian medical providers need to understand the differences and be trained to deliver medical care accordingly. Jeffrey Arnold, Medical Director of the Yale New Haven Center for Emergency and Terrorism Preparedness, stresses “it is prudent to ‘expect the unexpected,’ (but) an understanding of the epidemiological patterns in mass-casualty, terrorist bombings provides a rational basis for emergency planning, preparedness, and response” (Arnold, 2003, p. 221). Explosions are the most common case of casualties associated with terrorism (Arnold, 2003, p. 221). There have been very prominent bombings in the United States such as September 11, the Murrah building in Oklahoma City and the 1996 Atlanta Olympics that have been brought to the forefront of all Americans’ minds. The 1995 bombing of the Murrah Federal Building in Oklahoma City along with the 1996 Olympic bombing established very prominently that homegrown terrorism is a very valid issue in this country. Still, the civilian health care system views bombings as a relatively infrequent event. In actuality, bombings are far

more pervasive in this country than the few mentioned above. Between 1988 and 1997, there were 17,579 bombings in the United States, averaging five per day (Davis & Lee, 2004). As insidious acts of terrorism increase and become more frequent within U.S. borders, civilian medical providers must train to adjust medical care delivery accordingly to the specific situation just like their colleagues in the military Special Operations community.

As terrorists have become more sophisticated, extensive coordination allows numerous cities or sites to be targeted simultaneously, as was the case on September 11. When numerous cities are involved, the effect is dramatically augmented as numerous health systems are overwhelmed concurrently. Depending on the characteristics of the bombing, the local emergency medical resources can be easily overwhelmed. In the first 24 hours after the September 11 plane crashes in New York City, over 500 victims presented for emergency care at a hospital four blocks from ground zero, while another 300 sought care at the next hospital over which was within one mile (Pesola, 2002, p. 220). It is prudent that the lessons of military tactical combat care be studied.

What can be learned from military tactical combat care and can these tactics be applicable and beneficial in the civilian medical environment during a mass casualty event? The dramatically reduced lethality to war was accomplished by understanding the most common battlefield injuries and modifying trauma medicine to address trauma in a battlefield environment. Triage is based on survivability rather than treating the worst injured first. The traditional ALS paradigm of A-B-C-D has been strategically rearranged based on outcomes to be C-B-A. Medical care has been restructured to flexible and mobile. The FSTs are just behind the troops within the golden hour. Surgery and care is then done using damage control procedures. Ownership of the patient by the surgeon is given up in exchange for rapid transport of the soldier to definitive care at the CHS or in the United States. All these components together are referred to as TCCC and are strongly felt to be a significant contributing factor the reduction in war lethality.

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VII. ANALYSIS AND INTERPRETATION OF THE DATA

The analysis of mass casualty events in the trauma health care systems of the UK, Spain, Israel and the U.S. military allows for similarities and differences among the systems to be identified and correlations to be drawn as it relates to critical mortality. Obviously there are differences among each of the trauma systems in this paper, and these each differ from the civilian system in U.S. Regardless of the differences, numerous similar prominent findings were identified as positively influencing critical mortality. These fundamental findings include: triage accuracy, definitive care and damage control procedures. Triage accuracy is the correct and timely sorting and prioritization of victims that manages over-triage rates and eliminates under-triage rates. Definitive care is defined as the completion of all recommended or necessary care including the diagnosis, treatments and administration of drugs. A definitive care site is a medical facility that is able to provide this comprehensive level of care. Damage control procedures are when surgeries are incremental and are done to stabilize a victim until he or she can receive definitive care.

It is important to identify that critical mortality was low in all of the case studies delineated in this analysis despite the over triage rates being greater than the optimal 50 percent for the Spain and UK events. See Table 7.

Table 7. Critical Mortality of the Cases Studied

	Critical Mortality
Spain -11Mar04	17.2% (5/29) OT = 68%
UK—07Jul05	15% (3/20) OT= 63%
Israel	8.5%
U.S. Military	Reduced from 24% to 10% with the implementation of TCCC.

Examining the critical mortality rates listed above and comparing them to the graphic relation in Frykberg's article, each of these case studies demonstrates a reduction in critical mortality from other prominent terrorist attacks studied by Frykberg. As is depicted in Figure 7, Spain's event, with a critical mortality of 17.2 percent and the UK's event with a critical mortality of 15 percent were both beneath the line; indicating critical mortality in these two events was lower than would have been expected. Therefore, the countries must have been able to do something better and their approaches merit to be adapted and adopted.

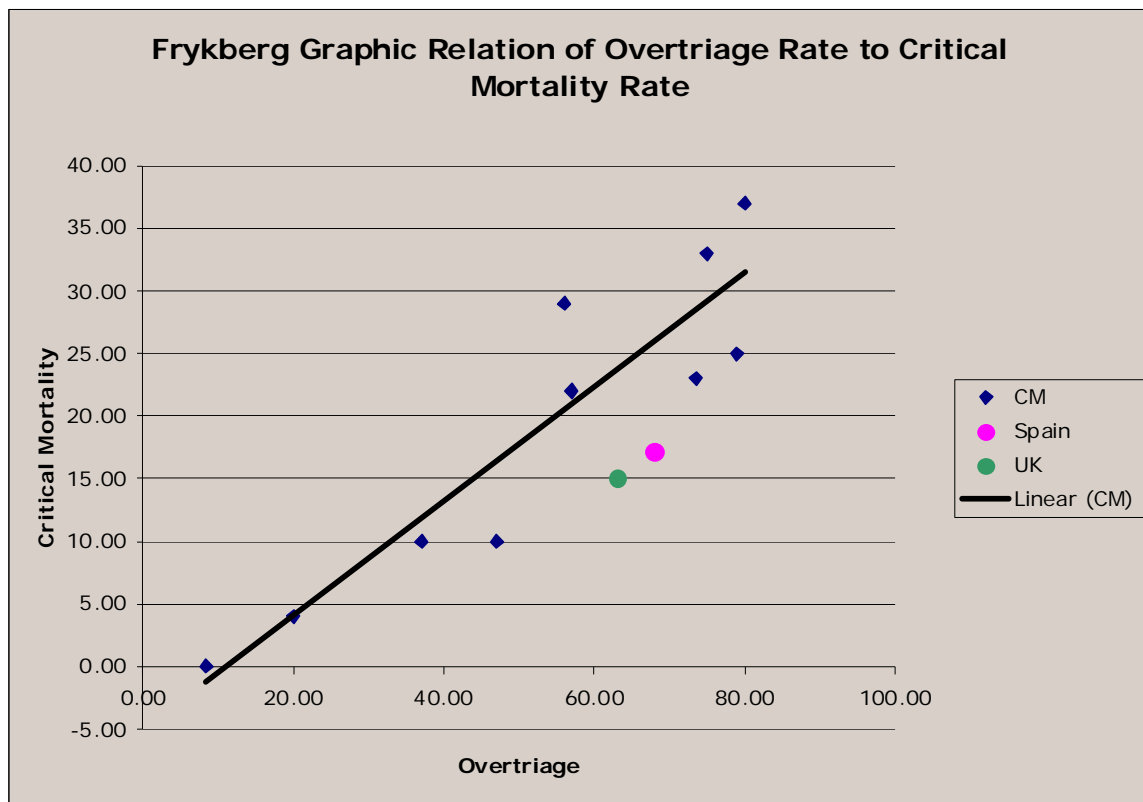


Figure 7. Linear Relation of Over-triage Rate to Critical Mortality (From Frykberg, 2002, p. 207)

Frykberg analyzed 10 terrorist bombings between 1968 and 1995. The linear correlation coefficient equals 0.92. Frykberg conducted his research prior to the events in Spain and the UK. Those points have been overlaid on this graph.

According to the graph calculated by Frykberg, the July 7, 2005 UK event, with an over-triage rate of 63 percent, would have been predicted to have a 23.5 percent critical mortality rate versus 15 percent (which extrapolates to four point seven deaths versus three deaths) and the March 11, 2004 Spain event, with an over-triage rate of 68 percent, a 26 percent critical mortality rate versus 17.2 percent (which extrapolates to seven point five deaths versus five deaths). This reduction in critical mortality translates into theoretical lives saved; one point seven lives in UK and two point five lives in Spain. See Figure 8.

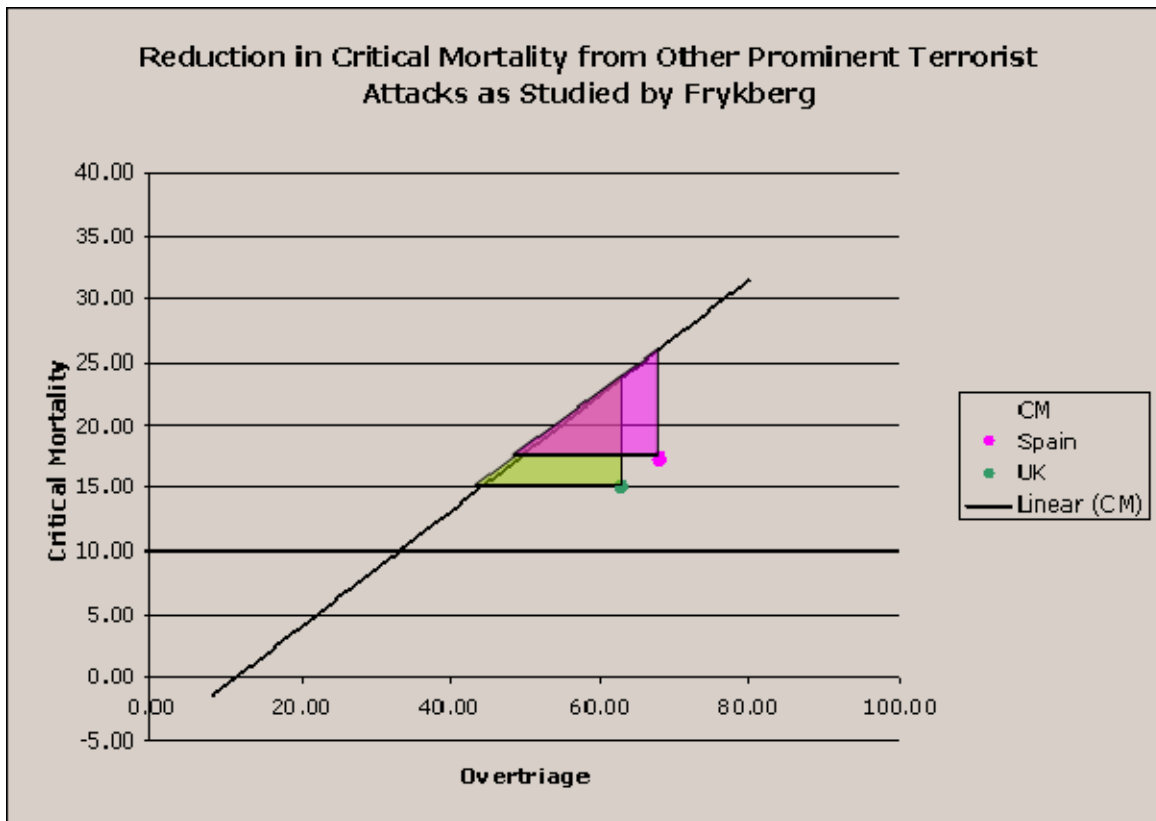


Figure 8. Reduction of Critical Mortality (After Frykberg, 2005)

Based on the research done by Frykberg, this graphic demonstrates the lives saved, through decreased critical mortality, from what would have been predicted. The colored areas under the line represent the lives that were salvaged.

The literature did not specify the over triage rates in the U.S. military or in the Israel study. Yet Figure 9 represents substantial decrease in critical mortality from prior

to the implementation of TCCC (24 percent) to after the implementation of TCCC (10 percent). The implementation of TCCC reduced critical mortality to nearly that of Israel, which had the lowest critical mortality at 8.5 percent of all the cases studied.

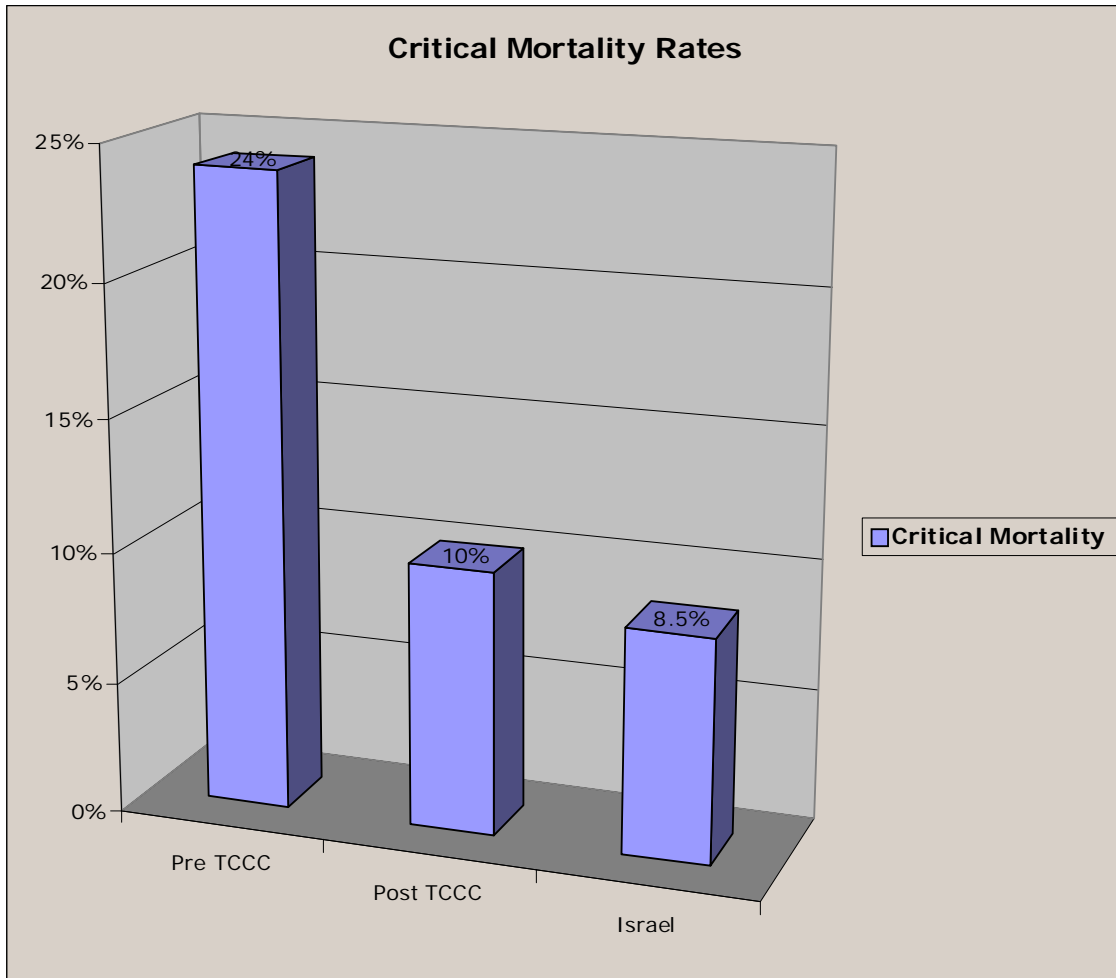


Figure 9. Reduction of Critical Mortality with the Implementation of TCCC

As discussed earlier, triage accuracy is the management of over-triage and the elimination of under-triage through effective rapid and repetitive triage. To optimize triage accuracy one must understand the conflict between rapid scene clearance and over-triage. The more rapidly a scene is cleared the greater will be the over-triage rate. Yet moving victims to definitive care within the golden hour positively influences critical mortality rates. Triage done by trained trauma staff improves triage accuracy.

In these case studies, the UK, Israel and the U.S. military have all addressed triage accuracy, each in a way that fits the characteristics of their environment and emergency system. The UK forward deploys trained emergency HEMS physicians to the site. This was cited as a predominate reason a low critical mortality rate of 15 percent occurred at the July 7 bombings.

Although Israel does not have physicians on all its ambulances, it does have physicians on its highest level MICU ambulance. In the very confined country of Israel where the population is centered near the major medical centers, Israel has opted for scoop and run to facilitate the expeditious movement of victims. One drawback is that the physicians on the MICU are not trauma physicians. To manage over-triage, they have their most skilled trauma providers in the trauma bays of the hospital conducting initial sorting and triage of the victims.

The U.S. military, through TCCC, has addressed triage accuracy by understanding the epidemiology of combat injuries and adjusting their practice to increasing survivability. Rather than continue practicing medicine based on the standards practiced in civilian medicine and provide all care necessary to the most injured victim, they have learned what is survivable and pour their resources into that population so as to salvage the most lives possible. Table 8 below details the interventions that each system has implemented that has improved triage accuracy.

Table 8. Triage Accuracy

	Triage Accuracy
Spain– March 11, 2004	Over-triage rate was determined to be 68% yet critical mortality was lower than what would have been expected. Triage was completed by the most experienced trauma specialists. Casualty distribution was well handled. Ample staff allowed victims to be triaged simultaneously.
UK – July 07, 2005	Forward deployment of London HEMS Staff. Scene clearance completed by qualified medical personnel. Continuous triaging and re-triaging to improve accuracy.
Israel	Forward deployment of trauma specialist at the trauma bay and MICU. Specialty of EM transitioned to a super-specialty. Modified trauma medicine to address gaps from the first Persian Gulf War and based on the epidemiology of blast injuries from terrorist attacks.
U.S. Military	Modified combat medicine specifically based on the epidemiology of combat injuries rather than civilian injuries.

The second predominant finding identified in the reduction of critical mortality is definitive care. These findings are outlined in Table 9 below. Again the UK, Israel, and the U.S. military have all addressed definitive care in their own systems. Rescuers are trained to get the victim and themselves out of the impacted scene as quickly as possible and get the victim to definitive trauma care without delay.

Because definitive medical care and equipment is not available in the field, the UK and Israel feel that pre-hospital interventions delay the time it takes the victim to reach definitive care, thus resulting in diminished outcomes. With their populations in urban centers near the hospital, the UK and Israel both employ scoop and run techniques. It is felt that pre-hospital procedure prolong transport time to definitive care and pre-hospital procedures being done by paramedics are not the most critical intervention that are needed for trauma victims suffering penetrating injuries. Scoop and run is a favorable system when the response time to definitive care is fast.

The U.S. military physician has learned to give up “ownership” of his or her patient. He or she relies on the network and system set up by the military to move the victim through the levels of care as needed. In understanding that they cannot provide definitive care in the field or even at the FST, surgery at the FST is done through damage control procedures. By not holding on to their patients, military doctors are able to perform damage control surgery urgently and then move them to the appropriate level of definitive care immediately thereafter. As is demonstrated by the practices of the military, damage control surgery and rapid movement to definitive care are inextricably linked and together they maintain capacity for future casualties.

Although Spain had the highest over-triage rate of the four cases examined at 68 percent, it still had a low critical mortality rate of 17.2 percent. In this case, it was determined that the nearest hospital lacked neither staff nor capacity. This is credited to its highly centralized national health system of hospitals and clinics. Through decentralized management Spain has been able to provide coordinated and collaborative services to its population, as well as to create and sustain regional preparedness. By having this level of regional preparedness, the health system resources were not actually constrained and were able to work as usual.

Table 9. Definitive Care

	Definitive Care
Spain – March 11, 2004	Hospital and staffing capacity was immediately available at the nearest hospital through regional preparedness.
UK – July 07, 2005	Scoop and Run.
Israel	Scoop and Run favorable in small nation. EM physician serves as Incident Commander. Uni-directional patient movement.
U.S. Military	Relinquishing “ownership” of soldier allows for more rapid movement to definitive care. Rapid evacuation to the FST. Uni-directional patient movement. FST within range to be within the golden hour. Time to move soldier from battle field to definitive care reduced by half (8 days to 4 days).

The third predominant finding identified in the reduction of critical mortality is the implementation of damage control procedures. In these case studies, initial operations were done in the “damage control” mode to expand the immediate resources to as many casualties as possible. Surgeries were done only to stabilize the victims rather than to provide all needed definitive care. This allowed the trauma center to optimize its surge capacity and provide life-saving care as quickly to as many people as possible. Subsequent surgeries were scheduled to occur after all the expected casualties had arrived or they were sent to other facilities. Hospital surge is able to be maintained for the duration of the event.

Damage control surgery, which has evolved over the past 20 years, is a most important advancement in trauma medicines. Like any change, it has been slow to catch on. Surgeons are accustomed to providing definitive procedures immediately. Yet research is indicating that outcomes are improved when the surgeries are shortened and incremental in nature. Recognizing that victims of trauma are more likely to die from metabolic failure, shortening the procedures allows for trauma victims to have their

metabolic imbalances corrected (Brohi, 2002). Table 10 below details the interventions that each system has implemented in the area of damage control. It is important to reiterate that damage control surgery and rapid movement to definitive care are closely related and augment one another while maintaining capacity in the system.

Table 10. Damage Control

	Damage Control Procedures
Spain– March 11, 2004	None noted.
UK– July 07, 2005	Immediate operations done only to stabilize the victim.
Israel	Scoop and run practice gets victim to trauma surgeons more quickly to perform damage control procedures.
U.S. Military	Triage based on survivability. Paradigm strategically rearranged C-B-A vs A-B-C-D. First step is to stop hemorrhaging and control contamination. “Ownership” of the soldier relinquished allowing surgery and care to be done with damage control procedures.

Fusing the analysis of these case studies allows tangible recommendations to be made to the U.S. health and medical communities on how best to adopt and implement standards of care for mass trauma care in the U.S.

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VIII. CONCLUSION AND RECOMMENDATIONS

Preparing for a mass-casualty event has captured the attention of policy makers, medical providers, accreditation bodies and the private sector. If current world events are any indication, the need to prepare for a terrorist-driven MCE has never been greater. Despite the experience of September 11, 2001, the U.S. trauma system lacks extensive experience with MCEs. Even though the hospitals in New York City surged to care for the expected victims of the twin towers, victims were either killed instantaneously or did not escape prior to the collapse of the structure. Medical staff ended up treating the walking wounded. Sadly, the U.S. trauma system remains woefully under-prepared. In order to expand and maintain surge capacity to handle a MCE in the U.S., efforts need to look beyond the tactical aspects and expand toward strategic changes that can be implemented at the national and regional levels rather than just at the individual hospital level. Preparing for a MCE requires the commitment of the federal government as well as the state and local health care systems.

A well-understood fact is that the nearest hospitals are quickly inundated. Ideally, the first level of trauma care should be initiated within the golden hour, utilizing scoop and run practices when most appropriate. These closest hospitals must serve as a casualty collection point—initiating triage and damage control interventions. Surgery should be staged and incremental preserving capacity for future incoming wounded. Patients should be distributed outward from the epicenter of the event to other predetermined facilities as centers for definitive care.

A. RECOMMENDATIONS

Based on evaluation of these four case studies, the U.S. civilian trauma care system needs to implement the following standards of care in response to MCE. These include:

1. Maintain and augment capacity
 - A. Regional coordination
 - B. Funding
2. Improved response procedure
 - A. Triage accuracy
 - B. Damage control procedures
 - C. Rapid movement to definitive care

B. IMPLEMENTATION

By definition, an MCE is an event that overwhelms local capacity over a defined period of time. Improving outcomes for trauma victims is predicated on the ability of local providers to access regional resources. Paramount is coordinated regional planning which will improve casualty distribution and outcomes. This planning needs to be regionalized so hospitals and health systems, which in the current system do not have a broad regional perspective, work together to create a cohesive system rather than independently to create fragmented or worse, competing systems.

The small geographic size of Israel makes it very unique and contributes substantially to the factors that contribute favorably to reduced critical mortality rates. Although the U.S. is exponentially larger than Israel, it is comprised of numerous cities. With regional preparedness and planning each of these cities could begin to realize the same benefits as seen in Israel. Urban centers must prepare regionally across jurisdictional boundaries to improve casualty distribution and expedite transport to definitive care. The benefits of this approach could be seen in Spain, where much of its success during the attacks on the transit system is attributed to the regionally coordinated and collaborative services provided to its population.

There must be recognition that emergency health care preparedness is as critical to the overall response system as is law enforcement, fire or ambulance services. Because the health system in the U.S. is predicated on private enterprise and free market

capitalism, it is impossible to expect local hospitals and health care systems to individually fund the cost of adequately preparing for the risks that are seen as being very unlikely to happen in any one place. Funding which has been provided to hospitals since late 2006 through the Hospital Preparedness Program (HPP) has incrementally improved individual hospital preparedness but has done little to build necessary regional coalitions for effective response during a MCE. Combined with the changes to Medicaid, the thin margin that hospitals must operate within is eroding. The Department of Health and Human Services needs to direct more funds to hospitals and health care systems specifically for creating and sustaining surge capacity. Local hospitals are the frontline providers when disasters occur. They need to provide, maintain and augment capacity and cannot expect external assistance in the first critical hours. Expecting the federal government to arrive instantaneously and relieve the local hospital or jurisdiction is a flawed assumption on numerous levels, as it proved to be in 2005 during Hurricane Katrina.

In non-crisis periods, most hospitals operate as definitive care sites. During MCE, facilities closest to the epicenter of a disaster must be able to transition to damage control procedures and be willing to move victims to other facilities radiating out from the epicenter. Broad regional pre-planning and coordination is critical for this dynamic switching to be effective. Furthermore, steps must be taken in the legislative arena which would protect facilities from litigation, promote collegial relationships and end the culture of patient “ownership” during MCEs. Only when hospital administrators are confident that they have effectively managed their own facility’s risk will they be willing to relinquish their individual positions and fold into the broader regional capacity.

Once there is an effective regionally coordinated plan for the distribution of victims, hospitals can focus on the real issue: improved outcomes. This objective can be reached through the enhancement of triage accuracy, management of damage control and implementation of definitive care. The U.S. military trains over 1,200 physicians a year in the principles of TCCC and over 7000 since September 2001 (Davis & Hadley, 2007). Returning medical providers, utilizing the principles of TCCC have demonstrated the value of the system for achieving improvements in decreasing critical mortality rates.

Their knowledge must be integrated into standards of care during MCE. These physicians and medics have gained valuable clinical knowledge and practice which must be capitalized upon for implementation within the civilian sector.

TCCC guidelines have not been used in the civilians sector as of yet. Although there are marked demographic differences between military combatants and civilian victims which are illustrated in Table 11, there is similarity in the epidemiology of the injuries and as such, battlefield medicine may serve an important role in preparing our civilian medical settings for terrorist MCEs. Of the medical staff returning from the wars in Iraq and Afghanistan, 50 percent are Reservists and Guards and another 20 percent have left the military to be civilians.(Davis & Hadley, 2007) Never have more U.S. providers had more MCE trauma experience than the present. Just as the U.S. military has changed its triage practices to focus on ‘survivability’ on the battle field, so must the civilian sector change their practices. Any MCE planning and preparedness strategy must include improving triage accuracy to include managing over-triage rates to be near 50 percent and eliminating under-triage rates to zero percent has been demonstrated to reduce critical mortality.

Table 11. Combatant versus Civilian (From Davis and Hadley, 2007)

	Military Combatant	Civilian Victim
Demographic of Injured	Mostly male, healthy, athletic, 18-35 years of age	More young, more older, more female and more in poor health
Personal Protective Equipment (PPE)	Helmet, armored vest, armored vehicles	No PPE or armor
Agent (Weapon Type)	Manufactured high-order (HE) military ordnance	Both makeshift low and high-order bombs
Injury Patterns	Well-studied. High tech shrapnel	Poorly studied. Nails, bolts, glass
Access to Care	Organized trauma care, long-term rehabilitation, and life long assistance. Advocate is in the President's cabinet.	Variable access to care, rehabilitation, or assistance. Advocacy is ad hoc.

The U.S. medical community must not assume that the rarity of terrorist events means planning is for naught. It behooves our medical community to learn from those who are facing terrorist attacks as a matter of course. Israel was forced, out of necessity, to change its trauma practices. They elevated trauma medicine to a super-specialty and have forwardly deployed this most qualified staff to the significant task of triage. Today Israel leads the world in the practice of trauma medicine and has the lowest critical mortality rates of the cases examined. The U.S. military has dramatically reduced its critical mortality rates between the last the two wars. Its rate is commensurate with Israel's. Strengths of the military model must continue to be examined for applicability in the civilian medical setting during MCEs.

It is imperative that medical professionals shape the strategy and define the procedures for a MCE, lest they be defined for them by the scope of the event or by the subsequent litigation. Efforts such as those undertaken by participants of the Task Force from the Mass Critical Care Summit must be applauded. By initiating the discourse, they

took ownership of a very sensitive and ethical dilemma facing the U.S. medical community. Having published the meeting, they take the first critical steps in the development of a comprehensive strategy to address care during a MCE. This summit must not be looked at as an end unto itself. It must be looked to as the beginning to an ongoing series of discussions that happen at a major, national scale.

The U.S. medical community must appreciate that a change in the standard of care during a MCE does not reduce overall care rendered. As demonstrated through the cases studied in this research, critical mortality was reduced due to improved triage accuracy, rapid movement to definitive care, implementation of damage control procedures and coordinated and collaborative regional preparedness. A comprehensive strategic assessment allows the paradigm of mass trauma health care delivery to focus on reducing critical mortality.

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